PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. X. 1879–80. No. 105.

Ninety-Seventh Session.

GENERAL STATUTORY MEETING.

Monday, 24th November 1879.

DAVID STEVENSON, Esq., M.I.C.E., in the Chair.

The following Council were elected:—

President.

The Right Hon. Lord MONCREIFF.

Vice-Presidents.

The Right Rev. Bishop Cotterill.
Principal Sir Alex. Grant, Bart.
David Milne Home, LL.D.
Sir C. Wyville Thomson, LL.D.
Prof. Douglas Maclagan, M.D.
Prof. H. C. Fleeming Jenkin, F.R.S

General Secretary—Professor Tait.

Secretaries to Ordinary Meetings.

Professor Turner.
Professor Crum Brown.

Treasurer—David Smith, Esq.

Curator of Library and Museum—Alexander Buchan, M.A.

Councillors.

Professor Rutherford.
Dr R. M. Ferguson.
Rev. W. Lindsay Alexander, D.D.
Dr Thomas A. G. Balfour.
J. Y. Buchanan, M.A.
Rev. Thomas Brown.
Robert Gray, Esq.
Dr William Robertson.
Professor Campbell Fraser.
Professor Geikie.
Rev. Dr Cazenove.
David Stevenson, Mem. Inst. C.E.

The following are *ex officio* Vice-Presidents, having filled the office of President:—

His Grace the DUKE of ARGYLL, K.T., D.C.L.
Sir ROBERT CHRISTISON, Bart., M.D., D.C.L.
Sir WILLIAM THOMSON, Knt., LL.D.

Monday, 1*st December* 1879.

The Right Hon. Lord MONCREIFF of Tulliebole, President of the Society, occupied the Chair, and delivered the following Opening Address:—

GENTLEMEN,—

I cannot, of course, commence the discharge of the duties of President of this learned and celebrated Society, without expressing my profound gratitude to the members for their unexpected kindness in elevating me to this chair, and my intense appreciation of the distinction they have thereby conferred upon me. It is a position of which any man, however high his reputation or however great his attainments, could not fail to be proud. To me your favour has laid me under the greater obligation, that I am painfully conscious that I am entirely without pretensions to the special qualities which have generally determined your choice. I am but a loiterer outside the temple of science, waiting for what it may please her priests to dispense to the crowd. My incursions into the fields of literature have been so rare, so desultory, and so clandestine, that I own myself more of a trespasser than one entitled to be there. Nevertheless, as fortunately for me your stamp has been impressed, it is not for me to gainsay so honourable and gratifying a dignity. The coin must pass current, whatever may be the intrinsic value of the metal. It may be, perhaps, that in the course of a life, not now to be reckoned short, spent in public and professional labours with various surroundings, I may, while little space has been left for cultivating the proper attributes of this chair, have acquired some knowledge of detail, some acquaintance with habits and springs of thought and action, which may be brought usefully to bear on the discharge of my duties. Be that as it may, I can only assure you that as far as my ability may reach, or industry and attention can serve me, I shall do my best not to discredit the appointment you have made.

For the rest, as regards the discharge of my duty to-night, I must ask you to make allowance for the suddenness with which it has overtaken me, and for the numberless distractions which have abridged even the short time I have had for preparation. I regret

this the more that there are some topics on which I should like to have enlarged, and which might have been appropriate to the occasion, and not without interest. I hope to have an opportunity hereafter of fulfilling more perfectly a duty which to-night must remain to a large extent unperformed. I understand that my being selected for this office to a certain degree is due to a desire on the part of the Society to vary for once the special qualifications which have hitherto been mainly looked for in your President, and to indicate a desire to revert to the literary side of the Society, as was contemplated in its original constitution. As far as the absence of any pretensions as a physicist is concerned, I no doubt may be a fitting representative of the desire so indicated, although the transition from the negative to the positive is much more doubtful. But I am to a certain extent consoled, in the sense of my own deficiencies, by finding that a professional position as a lawyer was once considered not without its recommendations in the choice of your members, or even in the selection of your President; for I find that the first meeting of the Society was held on the 23d day of June 1783, when the Right Hon. Thomas Miller of Barskimming, Lord Justice-Clerk, was chosen President of the meeting, and it was resolved that the Lords of Council and Session, and the Barons of Exchequer in Scotland, should be invited to a participation of the Society's labour, an invitation which, I am glad to think, was largely responded to at the time, and might with mutual advantage be more generally acted on now.

The theme which I should have chosen for this address, had I been able to cast it in anything of a systematic mould, would have been to consider how far it might be possible or expedient to widen or strengthen the literary character of this institution, and if so, in what direction, and towards what result this might be attempted. Times are greatly changed since the Society was formed, nearly a century ago. The prosecution of physical science, and the recording of its progress from month to month, must always be its chief development; for physical science is necessarily progressive, and every step taken is a step in advance. But with literature, or mental science, or political or social economy, or dialectics, it is not so; and if the meeting and if this Society were to exchange the weighty authority of its scientific transactions for the ephemeral

smartness of a literary institute, it would lose both in intrinsic interest and importance, and in public estimation. Still I think there is room for some good work to be done in relation to Scottish literature, being cognate to the grave and solid character which is and has always belonged to the transactions of the Society; and it had occurred to me, in searching for a suitable theme for my address from this chair, that some interest might be created by tracing in detail the rise and progress of English composition in Scotland. It is a subject which has never been thoroughly investigated or exhausted. We know more of Scottish literature in the sixteenth century than we do of that of the seventeenth. The period I should wish particularly to have illustrated is that long, and, as regards our own literature, rather dreary and barren chasm between the union of the crowns in 1603 and the union of the kingdoms in 1707. I should like to trace, if it could be done, the gradual steps by which our Scottish writers ascended from the strong, nervous, but Scottish vernacular of the 15th century, until, in the persons of Hume, Robertson, and Adam Smith—the founders of this Society—or among them, they became masters and models of the art, and gave laws, and canons of criticism, to the authors south of the Tweed. I have always looked on this result as a very remarkable instance of the tenacity and adaptability of the Scottish character. There can be no doubt that as regarded the arts and sciences, the more refined pursuits of the intellect, and the inducements to cultivate the gentler tenderness of knowledge, the union of the crowns in the first instance, and the union of the kingdoms ultimately, were a deep and severe blow. They withdrew money and patronage from Scottish enterprise in the markets of intellect as well as in those of commerce; and I incline to think that this cause, more than the troubles of the times, explains the lack of Scottish literature in the first half of the seventeenth century. The union of the kingdoms was a second and sudden discouragement to Scottish literature. Left without either court or parliament, and forced to conform to English models, authorship in Scotland became a very dreary affair. Scottish language, accent, phrases, and speech were the subject of perpetual derision to their southern neighbours, and the old Scottish pride of her authors could ill brook, while they could not withstand, the current of contemptuous criticism which assailed them. David

Hume speaks with great bitterness of the stings and "arrows" which galled him so much in London, compared with the deference and adulation which followed him in Paris. It has been said that the true secret of the leaning towards arbitrary power evinced by his History, especially in its later revisals, was inspired by the fact that James the First of England spoke broad Scotch, and that the English were unpleasantly proud of their free constitution. But the uses of adversity proved salutary. The Scotsmen had their revenge; for whatever may be thought of Hume's politics, his style remains to this day without a rival, and the same brotherhood of strong men who founded this Society, achieved a triumph in the fields of literature which remains a lasting monument of their power.

Such was the colour of my thoughts when I first became aware that I should have to-night to address you for the first time from this chair, and such were the lines on which, had my time permitted, I should have endeavoured to illustrate the literary side of your escutcheon. But the mere sketch which I have now outlined must I fear satisfy you that the task could not be performed with anything like success, without an amount of honest research to which my time has proved entirely inadequate.

STATISTICAL STATEMENT.

The following statement, in regard to the present Fellows of the Society, has been drawn up by the Secretary:—

1. Honorary Fellows:—

Royal Personage—

His Royal Highness the Prince of Wales, . . 1

British Subjects—

John Couch Adams, Cambridge; Sir George Biddell Airy, Greenwich; Thomas Andrews, M.D., Belfast (Queen's College); Thomas Carlyle, London; Arthur Cayley, Cambridge; Charles Darwin, Down, Bromley, Kent; John Anthony Froude, London; Thomas Henry Huxley, London; James Prescott Joule, Cliffpoint, Higher Broughton, Manchester; William Lassell, Maidenhead; Rev. Dr Humphrey Lloyd, Dublin; William Hallowes Miller, Cambridge; Richard Owen, London; Thomas Romney Robinson, D.D., Armagh; General Sir Edward Sabine, R.A., London; Henry John Stephen Smith,

Carry forward, —— 1

Brought forward, 1

Oxford; Professor Balfour Stewart, Manchester; George Gabriel Stokes, Cambridge; James Joseph Sylvester, Baltimore; Alfred Tennyson, Freshwater, Isle of Wight, ... 20

Foreign—

Robert Wilhelm Bunsen, Heidelberg; Michel Eugène Chevreul, Paris; James D. Dana, LL.D., New Haven, Connecticut; Alphonse de Candolle, Geneva; Franz Cornelius Donders, Utrecht; Jean Baptiste Dumas, Paris; Carl Gegenbaur, Heidelberg; Asa Gray, Cambridge, U.S.; Hermann Helmholtz, Berlin; Jules Janssen, Paris; August Kekulé, Bonn; Gustav Robert Kirchoff, Berlin; Hermann Kolbe, Leipzig; Albert Kölliker, Würzburg; Ernst Eduard Kummer, Berlin; Richard Lepsius, Berlin; Ferdinand de Lesseps, Paris; Rudolph Leuckart, Leipzig; Johann Benedict Listing, Göttingen; Joseph Liouville, Paris; Carl Ludwig, Leipzig; J. N. Madvig, Copenhagen; Henri Milne-Edwards, Paris; Theodor Mommsen, Berlin; Louis Pasteur, Paris; Professor Benjamin Peirce, U.S. Survey; Karl Theodor von Siebold, Munich; Otto Struve, Pulkowa, St Petersburg; Bernard Studer, Berne; Otto Torell, Lund; Rudolph Virchow, Berlin; Wilhelm Eduard Weber, Göttingen; Friedrich Wöhler, Göttingen, ... 33

Total number of Honorary Fellows at November 1879, ... —— 54

The following are the Honorary Fellows deceased during the year:—

Foreign.—Heinrich Wilhelm Dove, Johann von Lamont. M. Charles Dupin died in 1873.

2. Ordinary Fellows:—

Ordinary Fellows at November 1878, ... 385

New Fellows, 1878–79.—James Abernethy, Esq.; James Lambert Bailey, Esq.; Dr George William Balfour; James Blaikie, Esq.; John Calderwood, Esq.; Robert Cox, Esq., of Gorgie; William Denny, Esq.; Professor Cossar Ewart; Thomas Gilray, Esq.; John Hislop, Esq.; T. H. Cockburn Hood, Esq.; Dr Alexander Bennett M'Gregor; Dr Francis W. Moinet; J. B. Brown Morrison, Esq., of Murie; Major-General A. Cunningham Robertson; John

403

Brought forward, 385

Turnbull, Esq.; Dr John Charles Ogilvie Will; Dr Andrew Wilson, ... 18

Deduct Deceased.—Alexander J. Adie, Esq.; John Blackwood, Esq.; Dr Colledge; E. W. Dallas, Esq.; Dr J. G. Fleming; Edward J. Jackson, Esq.; Professor Kelland; Dr James M'Bain; Professor Clerk-Maxwell; Professor Nicol; Dr Montgomerie Robertson; J. F. Rodger, Esq.; Dr John Smith; Sir Walter C. Trevelyan; Arthur, Marquis of Tweeddale, ... 15

Resigned.—Professor Fuller; O. G. Miller, Esq.; Professor John Young, ... 3

18

Total number of Ordinary Fellows at November 1879, . 385

Add Honorary Fellows, ... 54

Total number of Ordinary and Honorary Fellows at commencement of Session 1879–80, ... 439

During the last session the Keith Prize for the biennial period 1875–77 was awarded to Professor Heddle for his papers on the "Rhombohedral Carbonates" and on the "Felspars of Scotland," originally communicated to the Society, and containing important discoveries. The Makdougall-Brisbane Prize for the biennial period 1876–78 was awarded to Professor Geikie for his memoir "On the Old Red Sandstone of Western Europe," which has been published in the Society's Transactions, and forms one of an important series of contributions by Professor Geikie to the advancement of geological science.

OBITUARY NOTICES.

The Rev. Professor Kelland. By Professors Chrystal and Tait.

Professor Kelland was the son of the Rev. Philip Kelland, who, at the time of the birth of his son, was rector of the parish of Dunster, in Somersetshire. Afterwards it would appear that he removed to Landcross, in Devonshire. Though an Oxford man himself, he sent his son Philip to Queen's College, Cambridge, where he greatly distinguished himself among his contemporaries, and in 1834 stood at the head of the honour list as Senior Wrangler and First Smith's Prizeman. Mr Kelland, who had taken orders in the Church of England, became Tutor of Queen's College, and held the post for

the next three years. In 1838 he was appointed to the Chair of Mathematics in the University of Edinburgh, as successor to Professor Wallace. He has been a Fellow of this Society ever since he came to Edinburgh; and only last year was elected to its highest office.

The loss which this Society suffered in the death of its President has already been characterised in fitting words by Sir Alexander Grant (*ante* p. 208). What we are now called upon to do, is to give a general account of his services alike to the University of Edinburgh and to science.

Kelland occupied the Mathematical Chair from the time of the resignation of Professor Wallace in 1838—a period including forty-one complete sessions. During six months of each year he gave at least thirteen lectures in all per week to his three classes; and for at least four sessions, during the illness of Professor Forbes, he conducted the Natural Philosophy course also. He was, besides, for long periods secretary of Senatus, and of the Board of Visitors of the Observatory, and was constantly employed in conducting examinations for various public bodies and institutions, *e.g.*, the Colleges of Physicians and Surgeons, the Dick Bequest, the Edinburgh High School, &c., and on several important occasions his services were engaged by one of the Scottish Insurance Offices with a view to the septennial investigation of its affairs from the actuarial point of view. In this connection he made a tour in Canada and the United States, of which he published an account in a charming little volume called "Transatlantic Sketches." If we add to this the labour entailed by his various published works and original scientific papers, as well as his constant contributions to educational publications, we can easily see what an active life he spent. To the very end of his career his activity never seemed to flag. His college duties grew from year to year, partly in consequence of the great increase in the number of students, but mainly because of the enormous increase of graduation. And he kept up, year after year, from 1869 at least, two Mathematical Classes for the Edinburgh Ladies' Educational Association. Yet his teaching was to the last as thorough as ever; and no better proof could be desired than the fact that three of the last four awards of the Ferguson Mathematical Scholarship, which is open to all the Scottish Universities, have been made in favour of Edinburgh students.

As Sir A. Grant has well said, he came to know the Scottish Universities better even than do Scotsmen themselves. To this we may add that he knew also, as few have ever known them, the characteristics and the wants of Scottish students. Our grief for his loss is at least tempered by the fact that he died at his post after an unusually extended term of active usefulness. He who has in person instructed, alike by clear precept and noble example, many thousands of the youth of a nation, cannot fail to have a happy and lasting influence on that nation's progress. Philip Kelland was, in the very highest sense, a benefactor to Scotland.

In spite of all his hard week-day work, he did not shrink from clerical duty on Sundays, very often reading the service, or preaching, in some of the Episcopal Churches in Edinburgh. In his sermons, as in his secular addresses, he was studiously quiet and simple, avoiding all mere popular arts of word-painting; but he was none the less effective in consequence. No one in the crowded Assembly Hall on the 22d April last, when he appeared for the last time before the public, can forget the profound impression produced on the whole audience by the few but earnest and loving words which he then addressed to the graduates. A fortnight later he was followed to his grave by the majority of those who had vociferously applauded his simple and touching eloquence.

His earlier mathematical work was very much influenced by his admiration for Fourier and Cauchy. The latter, indeed, was his personal friend. His *Theory of Heat*, and various elaborate papers in the "Camb. Phil. Trans." and the "Phil. Mag.," show how Kelland attempted to base the explanation of the phenomena of heat upon the mutual action of systems of particles exerting forces on one another at a distance. The analysis employed is of a nature very similar to Cauchy's; but we need not examine these attempts closely, for, though they show great mathematical ingenuity, they are now known to be based upon an unsound physical assumption.

He was much more successful when his physical assumptions were more accurate, as in his investigations of the motion of waves in canals, and in the calculation of the intensity of light which had passed through a grating. Another real service which he did to physical science consisted in his having edited and reprinted the

very valuable "Lectures" of Thomas Young. Kelland's edition is now unfortunately, like its predecessor, entirely out of print.

But his forte unquestionably lay in pure mathematics, and in that department, and others closely allied to it, he has enriched our "Transactions" with several very excellent papers.

An idea of Professor Kelland's scientific activity will be obtained by looking at the list of papers under his name in the Royal Society's Catalogue of Scientific Memoirs.

Several of his memoirs deal with physical optics. Two of these are especially interesting. They deal with the question of the aggregate effect of interference. In the first ("Trans. Camb. Phil. Soc." vii.) he shows that when light falls on a lens, part of which is covered and part uncovered, the whole quantity of light on a screen placed in the focus is to that which falls on the lens as the area of the uncovered part of the glass is to the whole area of the glass. Hence he infers that the whole quantity of light is not diminished or increased by interference. In the second ("Trans. R.S.E." xv.), starting from the principle thus established, he treats a very interesting point which arises in the application of Huyghens' principle in the undulatory theory. In forming the expression for the vibration due to any element of an aperture on the surface of a lens, we multiply the maximum intensity of vibration by the area of the element, and to keep the dimension correct we must divide by a factor D whose dimension is the square of a line. Kelland investigates a variety of cases for different forms of aperture, and finds in each case that D must be $b\lambda$ where λ is the wave-length of the incident light, and b the distance from the lens of the screen placed in its focus. The question was afterwards discussed by Stokes ("Trans. R.S.E." xx.), who generalised Kelland's analysis, and showed that the result may be deduced for an aperture of any form.

In a memoir read before the Royal Society of Edinburgh in April 1839 ("Trans." xiv.) Kelland took up the subject of wave motion. He discusses the case of a canal of finite depth h, adopting the hypothesis of parallel sections. Assuming the motion to be undulatory, and taking

$$z = h + a \sin \frac{2\pi}{\lambda}(ct - x)$$

for the equation to the surface, he deduces the approximate formulæ, in which $\alpha = \frac{2\pi}{\lambda}$,

$$c^2 = \frac{g}{\alpha}\frac{e^{\alpha h} - e^{-\alpha h}}{e^{\alpha h} \quad {}^{-\alpha h}} \cdot \frac{1}{1 - a^2\alpha^2(e^{\alpha h} - e^{-\alpha h})} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$a = \frac{2}{\alpha(e^{\alpha h} + e^{-\alpha h})} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

the first of which gives the velocity of transmission, the second the height of the wave.

In the latter part of the paper he applies his method to canals having a vertical section of any shape whatever, and deduces the following elegant formula—

$$c^2 = g\,\frac{\text{area of vertical section}}{\text{breadth at surface}}$$

for the velocity of propagation. This gives the result, for canals of triangular section, that the velocity of propagation is that in a rectangular canal of half the depth. This conclusion is tested by means of Scott-Russell's observations, and is found to be in close agreement with fact.

The same result was also arrived at independently by Green, who, in point of fact, anticipated Kelland in the matter, for he gives it in a note read before the Cambridge Philosophical Society on the 18th February 1839, whereas Kelland's paper was read on the 1st April of the same year. Scott-Russell's observations were the exciting cause of both investigations, which have little in common beyond this particular result.

In a memoir on General Differentiation ("Trans. R.S.E." xiv.), read December 1839, Professor Kelland deals with one of the most abstruse and difficult branches of analysis. The process by which we extend the meaning of the symbol x^m where m is integral to the case where m has any value whatever, is familiar enough, although it has its difficulties as every algebraist knows. General differentiation is a problem of a similar kind but of a much higher order of difficulty. Thus,

$$\frac{d}{dx}, \qquad \left(\frac{d}{dx}\right)^2, \qquad \left(\frac{d}{dx}\right)^3, \text{ \&c.,}$$

are symbols which have for their effect to deduce in a particular

way from any given function another set of functions, to which the name of first, second, third, &c., differential co-efficients are given. The corresponding problem here is to interpret the operating symbol,

$$\left(\frac{d}{dx}\right)^{\mu},$$

where μ may have any value whatever. This interpretation must be so made that it shall include the particular meanings already attached to the cases where μ is integral. This process of extension has been aptly called by De Morgan a case of the interpolation of forms, and there are difficulties in connection with it very like those that arise in the solution of functional equations or the inverse method of finite differences. The question was first raised by Leibnitz, and was treated successively by Euler, Laplace, Fourier, Liouville, Greatheed, Peacock, and Kelland.

The laws of operation to be conserved are—

$$D^{n}(u+v)=D^{n}u+D^{n}v,$$
$$D^{m}D^{n}u=D^{m+n}u.$$

The only question is:—What fundamental functions are we to select on which to base our calculus? It appears that different systems arise according as we select our fundamental functions. Peacock starts with x^{m}: Kelland, following Liouville and others, starts with e^{mx} as the ground function, and lays down the equation

$$\left(\frac{d}{dx}\right)^{\mu} e^{mx} = m^{\mu} e^{mx}$$

as the foundation of his system.

By means of a definite integral he then deduces the general formula

$$\left(\frac{d}{dx}\right)^{\mu} x^{-n} = \frac{(-1)^{n} \sqrt{n+\mu}}{\sqrt{n}\, x^{n+\mu}},$$

where $\sqrt{n}$ is a function like the gamma function, satisfying the equation

$$\sqrt{n+1} = n \sqrt{n},$$

but unlike it not restricted to positive values of n.

This formula is, then, applied in a variety of particular cases, and is shown to be perfectly general provided certain conventions are adopted, and from it are derived working formulæ convenient in different cases.

The theory is applied to the logarithmic and circular functions, and at the end of Part I. are given some very ingenious applications to expansions in fractional powers of x.

In Part II. is given the following extremely elegant formula—

$$\int_0^z d\theta\phi(\theta+a)(z-\theta)^p = (-1)^{p+1}\,\overline{|p+1}\cos(p+1)\pi\left(\frac{d}{dz}\right)^{-(p+1)}\phi(z+a),$$

which is applied to the solution of a variety of problems.

The whole of the mathematical work in this memoir is of great simplicity and elegance, and for that reason alone it is well worth the attention of students of the higher mathematics. It has, moreover, intrinsic value as an important contribution to the elucidation of a difficult branch of analysis. How great that importance may be it is impossible to estimate until the future of the method is more certain than it can at present be said to be; but, in any case, the work will remain a lasting monument to the skill and ingenuity of its author.

Closely connected with the paper just mentioned is another on a process in the differential calculus and its application to the solution of differential equations. Nothing farther need be said regarding it except that it is characterized by the same elegance and simplicity that mark the memoir on general differentiation.

Perhaps the most important of all Professor Kelland's scientific papers is his Memoir on the limits of our knowledge respecting the Theory of Parallels. He there deals with the subject now better known as absolute or non-Euclidean geometry. It would scarcely be possible to convey to those who have not busied themselves with pangeometry (or the geometry of pure reason as one might venture to call it, as opposed to the geometry of experience which is Euclid's) a full idea of the importance of this work of Kelland's, and of the evidence that it affords of his grasp of purely mathematical speculation. Suffice it to say that he reasons out correctly, and perhaps even more elegantly than is done in one of the last works on the subject,* the consequences of denying Euclid's "parallel axiom," or what is its equivalent, viz., the proposition that the sum of the three angles of any triangle is two right angles. It can be shewn by means of the properties of congruent figures, which, with all the consequences as

* Frischauf, "Elemente der Absoluten Geometrie."

to the nature of space that follow therefrom, are hereby assumed that—(1) The sum of the angles of any triangle can never exceed two right angles; (2) If the sum of the angles of any one triangle is two right angles, then the sum of the angles in every triangle is two right angles. But independently of the theory of parallels, this is in substance as far as we can go. If we assume that the sum of the angles of any triangle is less than two right angles, then we arrive at the conclusion that this sum depends on the area of the triangle, the defect from two right angles being less the less the area, and the same for all triangles of the same area, consequently therefore proportional to the area of the triangle. The effect of this assumption on the theory of parallels is very remarkable. Defining parallels as straight lines in the same plane that do not intersect (this is not the definition adopted in recent books, such as that of Frischauf, above named, but that is a mere question of words), we find that there are an infinite number of straight lines passing through the same point all parallel to a given straight line; that through one point on one of a pair of parallels only one straight can be drawn that makes the alternate angles equal; that parallel straight lines are not equidistant; that the locus of the points equidistant from a given straight line is not a straight but a curved line; that equal parallelograms on the same base cannot be between the same parallels, and so on. All this, and much more, is shewn by Kelland to form part of a system of geometry as logical as Euclid's.

As far as can be gathered from the memoir, and the form of the demonstrations, all but the fundamental propositions (the mere idea in fact) is Kelland's own work. It is characteristic of the man that he was in the habit of treating this subject in his class lectures.

Clearness in dealing with the fundamental principles of mathematical science was one of the virtues of Kelland's thinking and teaching. His text-book on *Algebra* is distinguished over other text-books in present use by its attempts to give a rational account of the first principles of the subject. The same readiness to grasp a new elementary idea, and trace its consequences, is exemplified by the fact that he took up Quaternions with his class in the University, and so late as 1873 published, in conjunction with Professor Tait, an excellent elementary treatise on this branch of mathematics. (See the *Preface* to that work.)

The minds of most men stiffen with age, and after a certain period the faculty of reception in most disappears. It was evidently not so with Professor Kelland.

Alexander James Adie, Esq. By David Stevenson, M.I.C.E.

Alexander James Adie, Civil Engineer, son of the late Alexander Adie, F.R.S.E., the eminent optician, was born in Edinburgh in 1808. A course of study at the High School, and afterwards at the University of Edinburgh, prepared him for entering on an apprenticeship under Mr James Jardine, Civil Engineer, with whom he was afterwards associated in carrying out various works.

In 1836 he became Resident Engineer of the Bolton, Chorley, and Preston Railway, and communicated some interesting papers to the Institution of Civil Engineers regarding that work, particularly one on Skew Bridges.

On leaving Lancashire he removed to Glasgow to take charge of some of the colliery railways there, and ultimately became engineer and manager of the Edinburgh and Glasgow Railway, which post he resigned about 1863.

Mr Adie made a series of important experiments on the expansion of stone by heat, which he communicated to the Society in his paper entitled "The Expansion of Different Kinds of Stone from an Increase of Temperature, with a Description of the Pyrometer used in making the Experiments," which is published in vol. xiii. of the Transactions.

Mr Adie was elected a Member of the Society in 1846. He latterly retired to reside at Rockville, near Linlithgow, where he had an opportunity of cultivating his taste for horticulture and the fine arts, and of receiving visits from many who esteemed his friendship, and valued his accomplishments.

John Blackwood, Esq. By Principal Sir Alex. Grant, Bart.

John Blackwood, who died on the 29th October last, was for a long period one of the most widely known and highly esteemed worthies of Scotland. As head of the last remaining of the great

Edinburgh publishing houses, he held an eminent and conspicuous position; his name was known and honoured all over the world; the circle of his acquaintance included almost all the most distinguished writers of the day, many of whom were his close and intimate friends; and the chorus of regret uttered by the London newspapers on the occasion of his death showed how widely and how much he had been respected. His life was externally uneventful. He was born in 1818; was educated at the High School and University of Edinburgh; travelled for three years under an accomplished classical tutor upon the Continent; commenced learning the publishing business with Messrs Whitaker in London in 1839; took charge of a branch of Messrs Blackwood's in Pall Mall in 1840; returned to Edinburgh in 1845, and became editor of "Blackwood's Magazine;" and in 1850 became head of the publishing firm in George Street. Happily married, and pursuing with conscientious diligence and great success the interesting duties of his position, keenly enjoying both work and relaxation, entering with equal zest into manly exercises and the intellectual pleasure of literary and witty conversation, to which he himself was no mean contributor, ever unselfish and taking an interest in others, diffusing much happiness among those who came within his range, he continued to exhibit till three years ago, when his health began to fail him, a career of high usefulness and a lot that was singularly blest. He continued in harness to the last, and within a few hours of his death was still reading the manuscripts of authors. He became a Fellow of the Royal Society of Edinburgh in 1857. He was never a contributor to the "Proceedings" of the Society. This, however, was only in accordance with the rule which he had laid down for himself, which was to abstain from authorship, in order to be able to estimate dispassionately and free from all feeling of rivalry the productions of others. Socrates used to say of himself that in matters of philosophy he performed the obstetric function for the youth of Athens, helping into existence such conceptions as were worthy to live and come before the world. The same sort of function John Blackwood performed for literature in this country. He was singularly fitted both by nature and education for the duties of his office. His knowledge of *belles lettres*, as well as of mankind, was extensive, and he had a remarkable sagacity in discerning

and foreseeing in the works of new writers, not only what was likely to be acceptable to the public, but what was essentially good in itself. During his thirty-four years of editorship and his twenty-nine years of publishing, he is said to have hardly ever made a mistake, while he frequently accepted works which had been rejected by other publishers, because he saw their merit, and the event proved him to have been right. In business transactions he was at once prudent and liberal, and always exhibited the qualities of a perfect gentleman. The result was a goodly and brilliant galaxy of great names in literature, who were his clients, and whose immortal works were first brought before the world under his auspices. The Royal Society of Edinburgh, one of whose objects is the encouragement of literature, must ever honour one who has been so faithful and valuable a servant and minister of the muses. And this Society, together with Edinburgh and the country at large, must deplore the loss of John Blackwood, than whom few men could have been less well spared.

JAMES CLERK-MAXWELL. By Professor Tait.

[JAMES CLERK-MAXWELL, born in 1831, was the only son of John Clerk-Maxwell of Middlebie. His grandfather, Captain James Clerk, was a cadet of the old Scottish family of Clerk of Penicuick, being a younger brother of Sir John Clerk of Penicuick. Captain James Clerk had two sons and a daughter—the Right Hon. Sir George Clerk of Penicuick, Bart., the above John Clerk-Maxwell, and Isabella, who married James Wedderburn, Solicitor-General of Scotland. Sir George Clerk succeeded to the estate of Penicuick, and the younger brother, John, to the estate of Nether Corsock, part of the estate of Middlebie. This estate had come into the family through the marriage in a former generation of a cousin of the Penicuicks with a Miss Maxwell. Their daughter married Sir George Clerk (grandfather of the present baronet) and was Lady Clerk-Maxwell. John Clerk assumed the name of Maxwell on succeeding to the property, which by the entail of Penicuick could not be held by the owner of that estate. John Clerk-Maxwell was called to the Scottish bar, but seldom practised, and he was a well-known member of this Society. He lost his wife soon after his

marriage, and lived a retired life, devoting himself to the care of his estates and the education of his son.]

When I first made Clerk-Maxwell's acquaintance about thirty-five years ago, at the Edinburgh Academy, he was a year before me, being in the fifth class while I was in the fourth.

At school he was at first regarded as shy and rather dull; he made no friendships, and he spent his occasional holidays in reading old ballads, drawing curious diagrams, and making rude mechanical models. His absorption in such pursuits, totally unintelligible to his schoolfellows (who were then quite innocent of mathematics), of course procured him a not very complimentary nickname, which I know is still remembered by many Fellows of this Society. About the middle of his school career, however, he surprised his companions by suddenly becoming one of the most brilliant among them, gaining high, and sometimes the highest, prizes for Scholarship, Mathematics, and English verse composition. From this time forward I became very intimate with him, and we discussed together, with school-boy enthusiasm, numerous curious problems, among which I remember particularly the various plane sections of a ring or *tore*, and the form of a cylindrical mirror which should show one his own image *unperverted.* I still possess some of the MSS. which we exchanged in 1846 and early in 1847. Those by Maxwell are on "The Conical Pendulum," "Descartes' Ovals," "Meloid and Apioid," and "Trifocal Curves." All are drawn up in strict geometrical form and divided into consecutive propositions. The three latter are connected with his first published paper, communicated by Forbes to this Society and printed in our "Proceedings," vol. ii., under the title "On the Description of Oval Curves, and those having a plurality of foci" (1846).

At the time when these papers were written he had received no instruction in Mathematics beyond a few books of Euclid, and the merest elements of Algebra.

The winter of 1847 found us together in the classes of Forbes and Kelland, where he highly distinguished himself. With the former he was a particular favourite, being admitted to the free use of the class apparatus for original experiments. He lingered here behind most of his former associates, having spent three years at the University of Edinburgh, working (without any assistance or supervision)

with physical and chemical apparatus, and devouring all sorts of scientific works in the library.* During this period he wrote two valuable papers, which are published in our "Transactions," on "The Theory of Rolling Curves," and "On the Equilibrium of Elastic Solids." Thus he brought to Cambridge in the autumn of 1850 a mass of knowledge which was really immense for so young a man, but in a state of disorder appalling to his methodical private tutor. Though that tutor was William Hopkins, the pupil to a great extent took his own way; and it may safely be said that no high wrangler of recent years ever entered the Senate-House more imperfectly trained to produce "paying" work than did Clerk-Maxwell. But by sheer strength of intellect, though with the very minimum of knowledge how to use it to advantage under the conditions of the examination, he obtained the position of Second Wrangler, and was bracketed equal with the Senior Wrangler in the higher ordeal of the Smith's Prizes. His name appears in the Cambridge "Calendar" as Maxwell of Trinity, but he was originally entered at Peter-House, and kept his first term there, in that small but most ancient foundation which has of late furnished Scotland with the majority of the Professors of Mathematics and Natural Philosophy in her four universities.

In 1856 he became Professor of Natural Philosophy in Marischal College, Aberdeen; in 1860, Professor of Physics and Astronomy in King's College, London. He was successively Scholar and Fellow of Trinity; and was elected an Honorary Fellow of Trinity when he finally became, in 1871, Professor of Experimental Physics in the University of Cambridge. There can be no doubt that the post to which he was ultimately called was one for which he was in every way pre-eminently qualified; and the Cavendish Laboratory, erected and furnished under his supervision, remains as remarkable a monument to his wide-ranging practical knowledge and theoretical skill as it is to the well-directed munificence of its noble founder.

If the title of mathematician be restricted (as it too commonly is)

* From the University Library lists for this period it appears that Maxwell perused at home Fourier's *Théorie de la Chaleur*, Monge's *Géométrie Descriptive*, Newton's *Optics*, Willis's *Principles of Mechanism*, Cauchy's *Calcul Différentiel*, Taylor's *Scientific Memoirs*, and many other works of a high order. Unfortunately no record is kept of books consulted in the reading-room.

to those who possess peculiarly ready mastery over symbols, whether they try to understand the significance of each step or no, Maxwell was not, and certainly never attempted to be, in the foremost rank of mathematicians. He was slow in "writing out," and avoided as far as he could the intricacies of analysis. He preferred always to have before him a geometrical or physical representation of the problem in which he was engaged, and to take all his steps with the aid of this: afterwards, when necessary, translating them into symbols. In the comparative paucity of symbols in many of his great papers, and in the way in which, when wanted, they seem to grow full-blown from pages of ordinary text, his writings resemble much those of Sir William Thomson, which in early life he had with great wisdom chosen as a model.

There can be no doubt that in this habit, of constructing a mental representation of every problem, lay one of the chief secrets of his wonderful success as an investigator. To this were added an extraordinary power of penetration, and an altogether unusual amount of patient determination. The clearness of his mental vision was quite on a par with that of Faraday; and in this (the true) sense of the word he was a mathematician of the highest order.

But the rapidity of his thinking, which he could not control, was such as to destroy, except for the very highest class of students, the value of his lectures. His books and his written addresses (always gone over twice in MS.) are models of clear and precise exposition; but his *extempore* lectures exhibited, in a manner most aggravating to the listener, the extraordinary fertility of his imagination.

During his undergraduateship in Cambridge he developed the germs of his future great work on "Electricity and Magnetism" (1873) in the form of a paper "On Faraday's Lines of Force," which was ultimately printed in 1856 in the "Trans. of the Cam. Phil. Soc." He showed me the MS. of the greater part of it in 1853. It is a paper of great interest in itself, but extremely important as indicating the first steps to such a splendid result. His idea of a fluid, incompressible and without mass, but subject to a species of friction in space, was confessedly adopted from the analogy pointed out by Thomson in 1843 between the steady flow of heat and the phenomena of statical electricity.

In recent years he came to the conclusion that all such analogies,

depending as they do on Laplace's equation, were best symbolised by the quaternion notation with Hamilton's ∇ operator; and in consequence, in his work on electricity, he gives the expressions for all the more important physical quantities in their quaternion form, though without employing the calculus itself in their establishment. I have discussed in another place ("Nature," vol. vii. p. 478) the various important discoveries in this remarkable work, which of itself is sufficient to secure for its author a foremost place among natural philosophers. I may here state that the main object of the work is to do away with "action at a distance," so far at least as electrical and magnetic forces are concerned, and to explain these by means of stresses and motions of the medium which is required to account for the phenomena of light. Maxwell has shown that, on this hypothesis, the velocity of light is the ratio of the electro-magnetic and electro-static units. Since this ratio, and the actual velocity of light, can be determined by absolutely independent experiments, the theory can be put at once to an exceedingly severe preliminary test. Neither quantity is yet fairly known within about 2 or 3 per cent., and the most probable values of both certainly agree more closely than do the separate determinations of either. There can now be little doubt that Maxwell's theory of electrical phenomena rests upon foundations as secure as those of the undulatory theory of light. But the life-long work of its creator has left it still in its infancy, and it will probably require for its proper development the services of whole generations of mathematicians.

The next in point of date of Maxwell's greatest works is his "Essay on the Stability of Saturn's Rings," which obtained the Adams' Prize in 1859. In this admirable investigation he shows that it is dynamically impossible that these rings can be solid, and also that they cannot be continuous liquid masses; the only other available hypothesis, viz., that they consist of multitudes of discrete parts, each a satellite, must therefore be the correct one.

Another subject which he treated with great success, as well from the experimental as from the theoretical point of view, was the Perception of Colour, the Primary Colour sensations, and the Nature of Colour Blindness. His earliest paper on these subjects bears date 1855, and the seventh has the date 1872. He received the Rumford Medal from the Royal Society in 1860,

"For his Researches on the Composition of Colours, and other optical papers." Though a triplicity about colour had long been known or suspected, which Young had (most probably correctly) attributed to the existence of three sensations, and Brewster had erroneously* supposed to be objective, Maxwell was the first to make colour-sensation the subject of actual measurement. He proved experimentally that any colour C (given in intensity of illumination as well as in character) may be expressed in terms of three arbitrarily chosen standard colours, X, Y, Z, by the formula

$$C = aX + bY + cZ.$$

Here a, b, c are numerical coefficients, which may be positive or negative; the sign = means "matches," + means "superposed," and − directs the term to be taken to the other side of the equation.

The last of his greatest investigations bore on the Kinetic Theory of Gases. Originating with D. Bernoulli, this theory was advanced by the successive labours of Herapath, Joule, and particularly of Clausius, to such an extent as to put its general accuracy beyond a doubt. But by far the greatest developments it has received are due to Maxwell, part of whose mathematical work has recently been still further extended in some directions by Boltzmann. In this field Maxwell appears as an experimenter (on the laws of gaseous friction) as well as a mathematician. His two latest papers deal with this branch of physics; one is an extension and simplification of some of Boltzmann's chief results, the other treats of the kinetic theory as applied to the motion of the radiometer.

He has written an admirable text-book of the "Theory of Heat," which has already gone through several editions, and a very excellent elementary treatise on "Matter and Motion." (See, again, "Nature," vol. xvi. p. 119.) Even this, like his other and larger works, is full of valuable matter, worthy of the most attentive perusal not of students alone but of the very foremost scientific men.

* All we can positively say to be erroneous is some of the principal arguments by which Brewster's view was maintained, for the subjective character of the triplicity has not been absolutely *demonstrated*.

Of his other scientific work, which extended over the whole range of physics, I may specially mention the following papers :—

On the transformation of surfaces by bending, "Camb. Phil. Trans.," 1854.

The discovery of the production of double refraction in viscous liquids ("Proc. R.S.," 1873), a late consequence of some of the results of his early paper of 1850.

A general theory of optical instruments, "Quart. Journ. of Math.," 1858.

On reciprocal figures, frames, and diagrams of forces, "Trans. R.S.E.," 1872. For this paper he obtained the Keith Prize.

His share in the construction of the British Association units of electric resistance, and in the admirable reports of the committee. Also his experimental verification of Ohm's law.

For further particulars recourse must be had to the Royal Society's Catalogue of Scientific Papers.

To these may now be added his numerous contributions to the latest edition of the "Encyclopædia Britannica"—Atom, Attraction, Capillarity, &c.; and the laborious task of preparing for the press, with copious and very valuable original notes, the "Electrical Researches of the Hon. Henry Cavendish." This work has appeared only within a month or two, and contains many singular and most unexpected revelations as to the early progress of the science of electricity.

The works which we have mentioned would of themselves indicate extraordinary activity on the part of their author, but they form only a fragment of what he has published; and when we add to this the further statement, that Maxwell was always ready to assist those who sought advice or instruction from him, and that he has read over the proof-sheets of many works by his more intimate friends (enriching them by notes, always valuable and often of the quaintest character), we may well wonder how he found time to do so much.

Maxwell's early skill in versification developed itself in later years into real poetic talent. But it always had an object, and often veiled the keenest satire under an air of charming innocence and *naive* admiration. No living man has shown a greater power of conden-

sing the whole substance of a question into a few clear and compact sentences than Maxwell exhibits in his verses. As an exceedingly good example of his style we may quote the lines written for the portrait of Cayley, now in Trinity College, Cambridge.

> "O wretched race of men, to space confined!
> What honour shall ye pay to him whose mind
> To that which lies beyond hath penetrated?
> The symbols he hath formed shall sound his praise,
> And lead him on through unimagined ways
> To conquests new in worlds not yet created.
>
> "First, ye determinants in ordered row
> And massive column ranged before him go,
> To form a phalanx for his safe protection.
> Ye powers of the *n*th roots of -1,
> Around his head in endless cycles run,
> As disembodied spirits of direction.
>
> "And you ye undevelopable scroles,
> Above the host wave your emblazoned rolls,
> Ruled for the record of his bright inventions.
> Ye cubic surfaces, by threes and nines,
> Draw round his camp your seven-and-twenty lines,
> The seal of Solomon in three dimensions.
>
> "March on, symbolic host, with step sublime,
> Up to the flaming bounds of space and time;
> There halt, until, by Dickenson depicted
> In two dimensions, we the form may trace
> Of him whose mind, too large for vulgar space,
> In *n* dimensions flourished unrestricted."

Other exquisite specimens are given in "Nature:" especially good is his "Lecture to a Lady on Thomson's Reflecting Galvanometer." One of the few others which have been printed was secured by John Blackwood for his Magazine, where it appeared under the title "British Association, 1874," in November of that year.

It is to be hoped that these scattered gems may be collected and published, for they are of the very highest interest, as the work during leisure hours of one of the most piercing intellects of modern times. Every one of them contains evidence of close and accurate thought, and many are in the happiest form of epigram.

I cannot adequately express in words the extent of the loss which his early death has inflicted not merely on his personal friends, on this Society, on the University of Cambridge, on the whole scientific world, but also, and most especially, on the cause of common sense,

of true science, and of religion itself, in these days of much vain-babbling, pseudo-science, and materialism. But men of his stamp never live in vain; and in one sense at least they cannot die. The spirit of Clerk-Maxwell still lives with us in his imperishable writings, and will speak to the next generation by the lips of those who have caught inspiration from his teachings and example.

Scotland may well be proud of the galaxy of grand scientific men whom she numbers among her own recently lost ones; yet even in a company which includes Brewster, Forbes, Graham, Rowan Hamilton, Rankine, and Archibald Smith, she will assign a place in the very front rank to James Clerk-Maxwell.

Dr Thomas Richardson Colledge.

Dr Thomas Richardson Colledge died on the 28th of October at Lauriston House, Cheltenham, in the eighty-third year of his age. He was a pupil of Sir Astley Cooper, and entered upon his profession sixty-two years ago; nor did he wholly relinquish his practice until 1878. To him, during his practice in Canton and Macao, belongs the merit of originating the first infirmary for the indigent Chinese, which was called after him "Colledge's Ophthalmic Hospital." He was also the founder of the Medical Missionary Society in China, and continued to be president of that society to the time of his death—a period of forty-two years. He laboured in Canton and Macao for more than twenty years, first under the Hon. East India Company, and then under the Crown as surgeon to His Majesty's Superintendents. On the abolition of the office he had held, and his consequent return to England, deep regret was expressed by the whole community, European and native, and a memorial of his services was addressed to Her Majesty the Queen in 1838 by the Portuguese of the neighbouring settlement of Macao. Lord Palmerston, in recognition of his services and merit, thought it right to award him an annuity. Dr Colledge took the degree of M.D. in 1839, and became F.R.C.P. of Edinburgh in 1840, and F.R.S. of Edinburgh in 1844. The last thirty-eight years of his life were spent in Cheltenham, where he won universal esteem by his courtesy and skill.

Elmslie W. Dallas, Esq. By General Robertson and Professor Piazzi Smith.

Elmslie William Dallas, the second son of William Dallas an underwriter at Llyod's, was born in London on 27th June 1809. He was educated at the Academy of Inverness, where he lived with his aunt, Mrs Sweetland, widow of General Sweetland; afterwards for a short time he attended classes at a commercial academy in London.

In his twenty-second year he decided to follow art as a profession, and was admitted a student of the Royal Academy in 1831. He completed his Academy studies in 1834.

The next six years (1834–1840) were spent on the Continent. During this time he resided a winter in Munich, nine months in Venice, and three years in Rome and its neighbourhood; he also spent several weeks at Dresden and Florence, and visited many other German, Flemish, French, and Italian cities. Several portfolios filled with highly-finished water-colour copies of the most celebrated pictures in the galleries he visited, and also with original drawings, sketches, and etchings, remain to testify the industry and skill with which during these six years the young artist pursued his studies.

In 1838 (æt. 29) he exhibited his first picture at the Royal Academy—it represented the interior of a Roman convent.

Soon after his return to England in 1840, he was employed by Herr Grüner to assist in the decoration of the garden pavilion at Buckingham Palace.

In 1841–42 he sent some pictures to the Royal Scottish Academy, which were well received and sold. In consequence of this success he resolved to settle in Edinburgh, and from 1842 until his death (*i.e.*, from his thirty-third to his seventieth year) he continued to reside there. For the next sixteen years (1842–58) he was a regular contributor to the annual exhibitions of the Royal Scottish Academy. His chief pictures were highly-studied interiors and mediæval subjects. There were also several landscapes, notably some views of the Campagna and its ruins. His last picture was exhibited in 1858 (æt. 50).

On 17th June 1846 he was appointed-assistant master of the architectural and ornamental class of the School of Design under

the Board of Manufactures. This appointment he held until 30th September 1858, when he was placed in retirement by the Treasury in order to carry into effect the affiliation of the school with the Science and Art Department of South Kensington. His connection with this school, therefore, extended over a period of twelve years (æt. 37–49).

On 3d March 1851 he was elected a Fellow of the Royal Society, to which he continued to belong until his death.

On 16th June 1859 (æt. 50) he married Jane Fordyce, eldest daughter of the late James Rose, W.S. Soon after his marriage he commenced the practice of photography as a profession, and applied the process of carbon-printing, with great success, to the illustration of books.

In 1870 (æt. 61) his health, which had previously been very good, was severely shaken by blood poisoning from bichromate of potash used in the process of carbon printing.

In 1872, when smallpox was prevalent in Edinburgh, he caught the infection from one of his assistants, and had a very severe attack of that disease. In the autumn of 1877, while on a visit to London, he had a very serious attack of typhoid fever, and never thoroughly recovered from the prostration of strength which followed the fever. The long-continued cold of the winter of 1878–79 tried him greatly. An attack of inflammation, brought on by a cold caught in January 1879, was the cause of his death, which took place at Dean-bank House on the 26th day of that month.

Such were the incidents in the uneventful but by no means unworthy life of Elmslie William Dallas. As regards pecuniary results it was a life of unsuccessful effort; but as regards the spirit in which the work of his life was done, and the intrinsic value and perfection of that work, E. W. Dallas's efforts to do well and thoroughly things worthy to be done, accomplished much that was admirable, in a manner that was most instructive and exemplary to all who had opportunities of observing the wealth of earnest lucid thought and the patient skilfulness of hand with which he worked out his results.

On 2d February, the Sunday following his funeral, the Rev. John M'Murtrie, speaking from the pulpit of St Bernard's, in which church Mr Dallas had been for upwards of ten years an elder,

said :—"His beautiful features, his grave almost sad expression, as of one who had fought life's battle and was wearied, were familiar to us all; but most of us could only guess at the worth, the truth, the goodness which lay under that reserved demeanour, for he shrank from prominent positions, and had that low estimate of his capacity for public affairs which often characterises the very best. But whatever he undertook he carried out thoroughly. His was a pure and chastened life; its brightest side not seen by the world, but shining in his own home for those who were dearest to him. In severe illnesses—of which he had several—he was gentle and patient; but I never knew how brave he was till I saw him face the last enemy without fear, in lowly trust in his blessed Saviour."

Professor Piazzi Smyth, who knew him well and had intercourse with him more or less frequent for a period of upwards of thirty years (from 1846 until his death), thus bears testimony to what he terms "the high calibre of his character."

E. W. Dallas was (the Professor says) undoubtedly a remarkable man: gifted with a *naive* simplicity of mind and thorough goodness of heart, as well as with no uncertain abilities of head and hand. Each singly of an admirable kind, and collectively very rarely found combined in the same individual. Yet so modest and retiring withal, was the possessor of them, that these rare abilities were little known.

The mere extent of his knowledge in the fine arts, and the great number of his acquisitions in the exact sciences, were, to say the least of them, very noticeable. But still more noticeable was the thorough soundness of his knowledge of every subject he had studied; so that I find now, on looking back through the years that are gone, this far higher commendation for him than any amount of local success or of temporary celebrity; viz., that almost whatever he said, or did, at any time, has stood: having been proved by subsequent experience to be true; and I have never regretted any moments I have spent in his company, either listening to his opinions or discussing his views.

I first met him in his capacity as a teacher of the architectural and ornamental class in the Trustees' School of Design, in the Royal Institution. The outlines to be copied were of large size, of classical severity, and yet not without poetical feeling; and he taught with

success, both morning and evening, a class of between seventy and eighty youths.

Equally skilful was he at home in modelling exquisite ideal forms in clay or wax; or in carving in wood, some of Nature's choicest leaves and flowers, with a delicacy of imitation which made a charming approach to the beauty of the originals.

At other times he would take up his palette and either paint landscapes from notes of former continental travel; or produce figures, usually of the *genre* kind, which testified to his possession of considerable powers of imagination, and of a lively memory well stored with reminiscences of extensive mediæval reading. Here, then, we have at once powers of multifarious work, extending over a very considerable range of the fine arts; enough of itself to have fitted out most successfully for the battle of life, many an aspirant for fame. But to all these artistic faculties, Elmslie W. Dallas added mastery of not a few branches of hard science; as thus—

1. He wrote a book on applied Geometry for the use of the School of Design, showing complete knowledge of the latest continental developments of the subject.*

2. He prepared papers on the optical mathematics of lenses.

3. He entered at one time with zeal and fervour into the casting, grinding, and polishing of the specula of reflecting telescopes.

4. He made experiments in improving and adapting compound microscopes to special subjects of minute anatomy.

5. He possessed a considerable range of chemical knowledge, and made many experiments, both on large and small scale, in crystallogenesis.

* In a report upon this treatise submitted to the Board of Manufactures on 17th June 1860, the late Professor Kelland writes :—"Regarded as a book of reference, which shall contain all the more important solutions of the ordinary problems of Practical Geometry, this treatise deserves very high commendation. The constructions adopted by the author seem in all cases to have been well selected; and the arrangement, founded on a classification of results, is eminently adapted to afford facility of reference."

The Professor, however, reported that, considered as an educational treatise, he did not think its arrangement suitable for the instruction of youth; and the result has confirmed this judgment. As a class-book, Mr Dallas's treatise has been superseded in the School of Art by a much less elaborate and more elementary little book compiled by Mr J. S. Rawle, Headmaster of the Nottingham Government School of Art.

6. He prepared grandly illustrated papers on the minuter forms of microscopic infusoria.

7. Long before he adopted photography as a profession, and when very few persons in this country knew anything about it, he had become conversant with the then newly-born art in all its chemical, as well as its optical and mechanical details; and he had prepared, with his own hands, special and instantaneous apparatus for applying it, on the one hand to record sun-spots as shown by a telescope; and on the other hand, to picture microscopic images of his favourite forms of naviculæ.

Now, how could any ordinary man occupy himself with all these arts and sciences, without being more or less shallow in some, and proving an undesirable leader or adviser in others of them?

It would be impossible! and yet so conscientious a student and thorough a worker was E. W. Dallas, that he possessed skill and solid acquirements in them all. Without pretension or direct effort on his part, he was looked up to, as rather a notable authority, in all of them, by many persons who prosecuted only one or other single subject out of the many with which our late Fellow was conversant.

At a meeting of the first Edinburgh Photographic Society, established by the late Sir David Brewster, when a novel kind of landscape lens, invented by that very original genius the late Mr Sutton, was laid on the table, how the members in general were non-plussed! It was a fluid-corrected, achromatic, globular lens with "butterfly diaphragm" stop, and producing equal illumination and good definition over three times as wide an azimuthal angle as had ever before been obtained. Presently Elmslie W. Dallas entered the room and sat down in a quiet corner, when it was perfectly delightful to me (a non-professional looking on) to see how several of the best men in the room brought the lens to *him*, told him all their hopes, fears, and difficulties about it, and then hung expectant on his words as though they would prove infallible—and if he spoke at all, his words, on such a matter, might be accepted as infallible. For although, not only when questioned privately but also in public, he was often sufficiently discourseful, yet he could be silent when he chose; and would not let popular applause, or personal requests, or hope of gain move him to give out a single opinion on any

subject, further than he himself had examined into it, after his own thoroughgoing manner, and to the satisfaction of the special ideal aspirations of his own soul. And herein was the most individual trait of the man—the rare cast of mind which made him a most worthy member of the Royal Society of Edinburgh; yet caused his worldly success in life, to fall far below his intrinsic worth and high capacities.

Gifted by nature with a sensitive soul, responsive to the love of abstract truth and appreciative of ideal beauty; ever inclined to be generous beyond his means, and quite incapable, amidst higher surroundings, of bestowing serious and concentrated attention on petty affairs, he worked at his profession (photography) in a manner regardless of cost; and not so much for profit, as for the sake of the scientific interest he involuntarily felt in overcoming difficulties in the practice of the art. That he did, from such motives, procure the most marvellous lenses and the most elaborate apparatus; that he tried, with patient and often long-protracted and expensive experiments, every new method in photography, was to his honour as a lover of science; but was not to his advantage as a man of very limited means, whose income mainly depended on daily studio work of a more certain kind. And, more untowardly still for his success in securing an adequate income, this taste for perfection and power in all the objective of his art, was accompanied by a curious inner subjective state of mind,—by a kind of inward psychical craving, perpetually urging him to desire, that his knowledge of whatever he touched, should be if possible more than perfect: persuading him too, that in order to know thoroughly any particular thing in nature, he should not only know and handle the thing itself, but that to be quite certain about it, he ought also to become similarly acquainted with everything else existent which, though outwardly excessively like, was not in reality the very thing itself; and might in consequence, at some time or other, possibly deceive the unwary. Under the pure, but exacting, domination of which idea, carried as it was by him to an inordinately high degree, he appeared at last to think that, in the conduct of his scientific inquiries, his chief duty consisted rather in finding and proving a negative; than in either establishing any positive result, or in securing opportunities for the most brilliant mercantile success. Had he been heir to a large fortune he

would have rendered services of the most invaluable kind to the science of the age he lived in; for with his eminent skill, perseverance, and capacity for untiring labour, joined *then* to ample pecuniary resources, he would have followed up most exhaustively all the *least* inviting paths of thought and experiment. And whenever he had traced the objects of his investigation, step by step, both back to their sources, and onward to their final outcome and practical application, according to his own high ideas of efficiency in research, —he would have been equally ready, if the result of his labours proved to be something good, true, and workable, to present it as a free gift to others; but if the contrary, to keep all the disappointment to himself. And no self-sacrifice in thought or work would ever have weighed with him for a moment, if by such devotion he foresaw that the road to future success, through any very difficult labyrinth, would be made safer and straighter for others. But without any adventitious aids of either fortune or favour, E. W. Dallas did, in fact, to a very great extent, fulfil the noble part for which he was in a manner designed, and specially endowed, by nature. And living as he did, conscientiously, day by day such a life, his soul could not but be advancing *pari passu*, and maturing itself to the end of his appointed time here below.

His own work is finished; but his rare example has, without doubt, even unknown to himself, kindled the spark of progress and self-improvement in many another mind that was around him; and his noble qualities, not less *excelsior* in aim, but more practically applied, may reappear in his own family, in another generation, as well as in a different field of labour.*

Dr J. G. Fleming. By Dr Andrew Wood, Edinburgh.

Dr John Gibson Fleming, who for many years occupied a prominent position in Glasgow as a medical practitioner, at first in general practice and latterly as a consultant, was born there on the

* E. W. Dallas leaves behind him a widow, a son, and two young daughters (twelve and five years of age). In the term ending July 1879, his only son James passed out of the Royal Academy of Woolwich, first of the commission class of Cadets. Besides the Pollock gold medal and a sword of honour for general good conduct, he received prizes for excellence in five special subjects. James Dallas is now a Lieutenant in the Royal Engineers.

2d December 1809. He was sprung from a family which had been long settled in Glasgow, and whose names are often mentioned in its annals. He received the whole of his early education at the High School of Glasgow, and afterwards at the University. Subsequently he prosecuted his medical studies in the University under such eminent teachers as Thomas Thomson and Graham in chemistry, Jeffray in anatomy, Burns in surgery, Bodham in physic, Hooker, the elder, in botany, &c. After taking his degree of M.D. in 1830 he spent some time in Paris and other continental cities. Returning home, he in 1833 became a Fellow of that ancient body, the Faculty of Physicians and Surgeons of Glasgow. Ere long he succeeded in establishing himself in an extensive practice, and ever since then down to his decease he continued to practise in Glasgow with great acceptance. It may show the estimation in which he was held by his professional brethren of the Faculty that he was exceptionally elected again and again as its President. This estimation was still further shown in 1862 when he was elected its representative in the General Council of Medical Education and Registration. This honourable and responsible office he continued to hold for fifteen years, when he resigned, much to the regret as well of his colleagues in the council as of the fellows of the faculty. In that council he was not a very frequent speaker—for he did not lay claim to oratorical gifts—but when he did speak what he said was terse and marked by shrewd common sense and judiciousness, so that he was always listened to attentively by the council, amongst whom he was greatly esteemed.

He made few contributions to medical literature. In 1862, however, he published "Medical Statistics of Life Assurance, being an Inquiry into the causes of Death among Members of the Scottish Amicable Assurance Society from 1826 till 1860." In this work, which was very carefully prepared, he gave an analysis of the diseases which had proved fatal to the assured as compared with the general mortality. This was a valuable contribution to the medical department of life assurance, and was well calculated to aid the medical referees of assurance companies in the selection of lives for assurance.

Dr Fleming had ample opportunities of giving vent to his philanthropic feeling in the management of various charitable institutions

in his native city, especially the Royal Infirmary, in which, by the way, he had served for many years as surgeon and physician, and in which he introduced many improvements.

Down to the period of his last fatal attack of typhoid fever, by which he was cut off on the 2d of October 1879 after a brief illness, Dr Fleming continued to perform with wonted energy and ability his duties, professional and otherwise, and may truly be said to have died in harness. His loss was greatly regretted by a large circle of patients, by whom he was regarded with esteem and affection, and by the public of Glasgow generally. In conclusion, it may be truly said that the history of Dr Fleming is that of a career modest and uneventful, but useful, honourable, and successful to the last.

Arthur Hay, Marquis of Tweeddale.

By Robert Gray, Esq.

Arthur Hay, 9th Marquis of Tweeddale, F.R.S., and president of the Zoological Society of London, was born on the 9th November 1824. He was the second son of his father, the 8th Marquis, who was a distinguished soldier, and the first agriculturalist of his time. Having in his eighteenth year obtained a commission in the Grenadier Guards, Lord Arthur Hay, as he was then called, on attaining the rank of Captain about a year afterwards, went out to India as A.D.C. to his father, who was Commander-in-Chief at Madras. At the end of a few years service in this capacity he was appointed A.D.C. to the Governor-General Lord Hardinge, and served under him in the Sutlej campaign of 1845–46. He was present at the decisive battle of Sobraon, and on the conclusion of the Treaty, by which the British became possessors of the hill territory west of the Sutlej and Cashmere, he, with several of his brother officers, visited this part of the Himalayas—a journey which afforded him ample opportunities for prosecuting his favourite study, and making a large collection of the birds of the country.

During his residence in India, Lord Arthur Hay formed the acquaintance of the late Dr Jerdon, a distinguished Eastern naturalist, who was in the early part of his life Assistant-Surgeon at Fort St George. Subsequently he was on terms of intimacy with other eminent naturalists; but he does not appear to have published more

than two scientific papers previous to 1866. These two appeared in the *Madras Journal*, one in 1844–45 entitled "Descriptions of some supposed new or imperfectly described species of Birds," the other in 1847 entitled "Notice of the Habits of the Large Indian Boa or Rock Snake."

In 1862 Lord Arthur Hay assumed the title of Lord Walden on the death of his elder brother Lord Gifford, and for the next four years of his life was almost entirely occupied with his military and other duties, as indeed he had been for many years previously. He was present with his regiment at the various battles fought during the Crimean war, and passed through the whole of that memorable campaign with distinction. He took part in the siege of Sebastopol, and received, among other honours, the medal and clasp for the war, the Sardinian medal of valour, the Turkish war medal, and the fifth class of the order of the Medjidie. He was ultimately promoted in 1860 to a Colonelcy in the Grenadier Guards, but was placed on half pay in 1863. In 1866, after becoming a Lieutenant-Colonel of the 17th Lancers, he finally retired from the army, and betook himself to scientific pursuits. For the next ten years he resided at Chislehurst, during which period he contributed a most important series of ornithological papers to the "Proceedings and Transactions of the Zoological Society," the "Annals of Natural History," "Rowley's Ornithological Miscellany," "The Ibis," and other periodical magazines—many of these papers specially referring to the birds of India and the Eastern Archipelago.

Upon the death of Sir George Clerk in 1868, Lord Walden was elected President of the Zoological Society of London—an office in which he discharged his duties in the most efficient manner until his death.

Lord Walden succeeded to the peerage and estates on the death of his father in 1876; and at that time, having taken up his residence at the family seat, Yester, in Haddingtonshire, he entered upon the investigation of the avi-fauna of the Philippine Islands, at which subject he worked with extraordinary zeal, the result being a most valuable series of papers, thirteen in number, which appeared in the "Proceedings of the Zoological Society," the last of which was finished but a day or two before the author's death.

The papers of greatest value written by Lord Tweeddale appeared

between 1867 and 1878. These relate almost exclusively to descriptions, with figures, of new species of birds from various parts of the world, and are looked upon as the most important contributions to ornithological science that have been published during the same period in this or any other country. No one, indeed, can look upon the masterly work of Lord Tweeddale without feeling that by his sudden and premature death an irreparable loss has fallen upon the science to which he was devoted, and that many years must pass before ornithologists cease to deplore his untimely removal.

In 1877 Lord Tweeddale published fifteen separate papers on ornithological subjects, and in the following year about the same number—the fourteenth and last having, as already mentioned, been finished only a few days before his death. His loss, therefore, came upon the scientific world at a time when his writings were being regarded with a peculiar interest, and when he himself was everywhere being recognised as the most able ornithologist of his day.

Lord Tweeddale died at Walden Cottage, Chislehurst, on the 29th December 1878. His collections of birds, which are of great value, being the repository of a large number of type species described in the papers referred to, together with his valuable library of scientific works, are bequeathed to his nephew, Mr R. Wardlaw Ramsay, himself an ornithologist of considerable note.

Dr James M'Bain. By Robert Gray, Esq.

Dr James M'Bain was born at Logie, in Forfarshire, in November 1807. After having spent some years at the parish school of Kirriemuir, and about three years as an apprentice to a local surgeon, he entered upon the study of medicine at the University of Edinburgh in 1823. Three years later, namely, in March 1826, he passed his examination at Surgeons' Hall, and received his diploma when little more than nineteen years of age. About this time he removed to St Andrews, where he spent upwards of twelve months; and in the autumn of 1827 he was appointed assistant-surgeon to H.M.S. "Undaunted," just then commissioned to proceed to India with the newly-appointed governor, Lord William Bentinck. During this and a subsequent voyage in the same ship in 1829, to the Azores and Cape de Verde Islands, Dr M'Bain had but

limited opportunities of cultivating his taste for natural history pursuits, but such leisure as he enjoyed enabled him to collect various notes which, although not published at the time, became useful to him in after life.

In 1832, Dr M'Bain, in the capacity of assistant-surgeon, joined the "Investigator," a surveying ship, under the command of Captain Thomas, who was at that time employed in a survey of the Shetland Islands. This survey was completed in 1834, and was followed by a survey of the Orkney Islands, during which Dr M'Bain and Captain Thomas prosecuted a series of successful dredgings in deep water between the two groups of islands, as well as along their shores. Much interesting information and material resulted from their joint labours, extending over a period of sixteen years, and was freely communicated to Messrs Forbes and Hanley and Dr Harvey, who were then engaged in bringing out their important works on Molluscous Animals and British Seaweeds.

After settling for some years at Elie, in Fifeshire, and subsequently at Leith and Trinity, Dr M'Bain continued to devote his time and attention to the investigation of the marine fauna of the Firth of Forth; and while engaged in this he was the friend and frequent companion of Dr Fleming, Prof. Goodsir, Dr Strethill Wright, and other naturalists, who often accompanied him in his dredging excursions. During these years he took an active interest in the proceedings of the Royal Physical Society, of which society he was twice president, and contributed many papers of interest, which appeared at intervals from 1859 to the time of his death. He also contributed to a Topographical work by the Rev. W. Wood, Elie, entitled the "East Neuk of Fife," an important catalogue of the *Mollusca* of the Firth of Forth, embracing 344 species—244 of which were collected by himself; and while he was in the midst of such labours his friends had reason to regret that the state of his health and retiring modesty prevented him undertaking some independent work in which he might have done justice to his powers. He had an extensive knowledge of comparative anatomy, having at one period of his life enjoyed the advantage of studying under Professor Owen of London—a training to which much of the thoroughness of his knowledge as a naturalist may perhaps be attributed.

In private life Dr M'Bain was much esteemed by a large circle of friends. A man of extensive reading, amiable and unobtrusive in manner, he quietly prosecuted his practical work as a naturalist uninfluenced by any of the various theories which are not fully supported by facts. One scientific fact, indeed, to use his own words, was to him worth all the poetry in the world. He took a great interest in the scientific studies of young naturalists, and was at all times ready to give them the benefit of his counsel and wide experience. Many such students now mourn his loss in distant lands.

Dr M'Bain died, after a painful illness of some months' duration, at Trinity, near Edinburgh, on 21st March 1879.

Professor James Nicol. By Professor Archibald Geikie.

In the death of Professor James Nicol the Society has to regret the loss of one who served to link the present generation of geologists with the early leaders of the science in this country. Trained in this university under Jameson, he imbibed that love for the mineralogical side of geology which distinguished his career. His earliest scientific publication—an essay on the geology of his native county of Peebles—was awarded a prize by the Highland Society, and was issued in their "Transactions." At the time of its appearance very little had been added to the original observations of Sir James Hall, communicated to Hutton, and published in the "Theory of the Earth," regarding the structure and constitution of the so-called *schistus* or *killas*, forming the uplands of the south of Scotland. Mr Nicol, however, continued to devote himself to the investigation of this subject. He was the first to suggest that these rocks should be paralleled with some of the "Silurian" formations made known by the researches of Murchison; and in subsequent communications to the Geological Society of London he brought forward contributions to the unravelling of the complicated geology of these Silurian uplands of Scotland. At an early period of his life he published a small volume under the title of "Guide to the Geology of Scotland." Though chiefly compiled from the published memoirs of previous observers, it was a meritorious and useful work, giving within a small compass a trustworthy digest of

all that was known at the time upon the subject. A more important work was his well-known "Manual of Mineralogy" which has long been a standard book of reference.

His papers giving promise of much ability, he was appointed to the important office of Assistant Secretary of the Geological Society of London, where he came into intimate relations with the leading geologists of the day. Afterwards he became Professor of Geology at Queen's College, Cork—an office he soon vacated for the chair of natural history in the Aberdeen University, in the discharge of the duties of which he has spent the larger part of his scientific career.

For the last fifteen years he published scarcely any scientific papers, devoting his time principally to the business of the College, in which he took an active interest. During summer, however, he was in the habit of making excursions into the Highland mountains, where he renewed his acquaintance with minerals and rocks, which retained their interest for him to the last. Retiring in disposition, and latterly in somewhat enfeebled health, he allowed himself almost to drop out of the acquaintance of his fellow geologists, who rarely had an opportunity of seeing him save by visiting him at Aberdeen, or joining him in one of his Highland rambles. His unfailing kindliness and readiness to help others greatly endeared him to his students.

Dr John Smith. By Dr Batty Tuke.

Dr John Smith was born in the year 1798. His father combined the business of brassfounder and farmer, renting the Calton Hill and a few adjacent fields. It may be interesting to place on record that Dr Smith's father's mother was born in 1685, the last year of the reign of Charles the Second. He was educated at Heriot's Hospital, by the Governor of which institution he was recommended to Dr George Wood, son of the well-known Dr Alexander Wood, as an apprentice. He took the degree of Doctor of Medicine in the Edinburgh University in the year 1822, and became a Fellow of the Royal College of Physicians in 1833. After graduation he acted as Dr Wood's assistant, and eventually succeeded to his practice, which included the management of the Saughton Hall Asylum for the

Insane. He was also visiting physician to the old Charity Workhouse and City Bedlam in the Forrest Road. Dr Smith was elected President of the Royal College of Physicians in 1865. He died February 4, 1879. Dr Smith's contributions to the literature of medicine were not numerous, but were marked by extreme conscientiousness of observation. His most important papers are "An Account of Dysentery as it occurred in the Edinburgh Charity Workhouse during the years 1832 and 1833," and "Cases of Mental Derangement terminating fatally, with the Appearances disclosed by Inspection," both published in the Edinburgh Medical and Surgical Journal. Dr Smith was best known in his connection with the treatment of insanity, and he gained a considerable reputation in that special line of practice. It cannot be said that he displayed any great originality, his character being chiefly marked by accuracy, conscientiousness, and solidity, which qualities, however, added to great gentleness of disposition, procured him the respect and esteem of a large circle of friends, and the confidence of his professional brethren.

Sir Walter Calverley Trevelyan, Bart. By Dr Benjamin Ward Richardson, F.R.S.

Sir Walter Calverley Trevelyan, Bart., of Wallington in Northumberland, Nettlecombe in Somersetshire, Seaton in Devonshire, and Trevelyan in Cornwall, is another of the Fellows whom the Royal Society of Edinburgh has lost during the past year. The late Sir Walter was a scholar of the most refined taste and varied learning. His mind through all the stages of his long and active life was devoted to the acquirement and improvement of natural knowledge. He was born on the 31st of March 1797, his father being the fifth baronet of his line, and his mother a daughter of Sir Thomas Spencer Wilmot, Bart. Sir Walter commenced his university studies as an undergraduate at Oxford when he was about nineteen years of age, and in 1820 passed as Bachelor of Arts. Soon after this he visited the Faroe Islands, and wrote an account of them, including a record of their geology, vegetation, and climate. He also formed a collection of plants, making a fine herbarium,

which he presented in after years to the Botanical Museum at Kew.

In 1835 Mr Trevelyan married Paulina, the oldest daughter of the late Rev. Dr Jermyn, who lived until the year 1866.

After the British Association for the Advancement of Science had been founded in 1831, Mr Trevelyan took a deep interest in its progress. He served on the local committee of the Association when it met in Newcastle in the year 1838, and he was afterwards a member of the Council of that learned body. At the thirty-second meeting of the Association in the year 1862, he was elected one of the Vice-Presidents, his colleagues being Sir C. Lyell, Hugh Taylor, Isaac Lowthian Bell (Mayor of Newcastle), Nicholas Wood, the Rev. Temple Chevalier, and Mr (afterwards Sir William) Fairbairn.

Sir Walter came into possession of his estates and title in the year 1846, and from that time resided principally at his beautiful estate at Wallington, near to Cambo, Northumberland, a mansion of great historic note, and once the seat of a famous Jacobite, whose opinions cost him his life—Sir John Fenwick. He was elected Deputy-Lieutenant of the County in 1847, and in 1850 served the office of High Sheriff.

His time was much devoted to the improvement of agriculture and to the social amelioration of the condition of the people. He also took a deep interest in public affairs, and as far back as 1853 he became the first President of the United Kingdom Alliance for the suppression of the sale of intoxicating liquors, which office he continued to hold until his death.

In addition to his tastes for science, Sir Walter Trevelyan was a willing patron of the fine arts, and collected at Wallington some exquisite artistic works, in addition to a perfect museum of natural history. He was a Fellow of the Society of Antiquaries and a zealous antiquarian, and has left to the British Museum and the Society of Antiquaries valuable legacies. He was a clear and concise writer, and contributed several very useful papers on geological and botanical subjects. He was also a thoughtful and collected public speaker, who made every sentence he spoke tell, and who never wasted a sentence or, it may almost be said, a word.

In 1867 Sir Walter married, for the second time, Laura Capel, the daughter of Capel Lofft, Esq., of Troston Hall, Suffolk, who

survived him only for a few days. He had no issue, and his title has descended to his nephew, Sir Alfred W. Trevelyan of Nettlecombe, the present baronet. Wallington he bequeathed to his cousin, Sir Charles Trevelyan, K.C.B.

Sir Walter Trevelyan continued actively engaged in his various pursuits until March 1879. He suffered a very short illness, having been out a day or two before his death, and was occupied, indeed, with his correspondence on the morning of that day. He suffered, as it seemed, from a cold, accompanied with slight physical depression. In the course of March 23d he began suddenly to show signs of exhaustion, and sank into death without any continued sign of acute pain. He was in the eighty-third year of his age at the time of his death.

The late baronet was elected a Fellow of the Royal Society of Edinburgh in the year 1822.

Professor Heinrich Wilhelm Dove. By Alexander Buchan, M.A.

Professor Heinrich Wilhelm Dove was born at Leignitz, Silesia, on October 6th 1803, and at the age of eighteen passed from the schools of that town to the universities of Breslau and Berlin, where for the next three years he devoted himself assiduously to the study of mathematics and physics. In 1826 he took his degree of Doctor of Philosophy, his thesis on the occasion being an inquiry regarding barometric changes; and it is further significant of his future life-work that his first published memoir was a paper on certain meteorological inquiries relative to winds—these two subjects holding a first place in the great problem of weather-changes.

In the same year Dove entered on his public life as tutor, and in 1828 as Professor at Konigsberg, where he remained till 1829, being then invited to Berlin as Supplementary Professor of Physics. His strikingly clear-sighted, bold, and original intellect turned instinctively to that intricate group of questions in the domain of physics which comprise the science of meteorology, and his success in these fields as an original explorer was so marked and rapid that he soon achieved for himself a seat in the Royal Academy of

Sciences, and sometime thereafter was raised to the distinguished position of the chair of physics in the University of Berlin.

Among the scientific and fashionable circles of Berlin he took first rank as a lecturer, the combined qualities of accurate science, fine imagination, lucidity of style, commanding presence, and the extent over which his utterances were heard, marking him out as the Arago and Brewster of Germany. Germany showered on him in profusion those honours and offices which it gracefully and gratefully bestows on learning and science; and perhaps there is no learned or scientific society of note that has not Dove's name enrolled among its honorary members. After a protracted and hopeless illness he died on Friday April 4th 1879, in the seventy-sixth year of his age.

In the Royal Society's Catalogue of Scientific Papers the lists under Dove specify 234 memoirs, written between the years 1827–73. These show him to have been a successful worker and investigator in electricity, optics, crystallography, and in such practical matters as the metric systems of civilised nations. But it was to meteorological inquiries that he devoted his full strength and the whole powers of his mind, and by his herculean, but well-directed labours, he has written his name in large imperishable characters on the records of science.

His fame rests on the successful inquiries he carried out with a view to the discovery of the laws regulating atmospheric phenomena, which apparently were under no law whatever. The work he will be long best known by is his isothermals and isabnormals of temperature for the globe, in which work one cannot sufficiently admire the breadth of view which sustained and animated him as an explorer during the long toilsome years spent in its preparation. Equally characterised by breadth of view, and what really seemed a love for the drudgery of detail even to profuseness, when such drudgery appeared necessary or desirable in attaining his object, are various works on winds, the manner of their veering, and their relations to atmospheric pressure, temperature, humidity and rainfall, and the important bearings of the results on the climatologies of the globe; on storms and their connections with the general circulation of the atmosphere; the influence of the variations of temperature on the development of plants; and the cold weather of May—to which

may be added the valuable system of meteorological observations he gradually organised for Germany, and the many full discussions of these which he published from year to year.

It is no ordinary praise to pass on his work to say that those views he propounded, which subsequent researches are likely to modify materially, are those he arrived at by methods of investigations, necessarily defective, at the time. Thus, for instance, in inquiring into the law of storms, it was not in his power to work from isobaric charts, seeing that the errors of the barometers and their heights above the sea were only known in a very few cases. When we consider the condition in which he found man's knowledge of weather, and the large accessions and developments it received from his hand, the breadth of his views on all matters connected with the science, and the well-directed patience, rising into high genius, with which his meteorological researches were pursued, there can be but one opinion, that these give Dove claims which no other meteorologist can compete with, to be styled "the father of meteorology."

JOHANN VON LAMONT. By Alexander Buchan, M.A.

JOHANN VON LAMONT was a Scotsman by birth, having been born in Deeside on the Balmoral estate in 1805, of one of the oldest of our Scottish families. At the age of seventeen he left Scotland, to which he never returned, in the prosecution of his studies in connection with the Roman Catholic Church. Whilst a faithful and zealous member of the clergy of that communion, it was to the Exact Sciences he devoted the full powers of his singularly energetic and penetrating intellect. His first contribution to science was published in 1829, in the twenty-fourth year of his age, the subject being the Motions of Encke's Comet, and from that date to 1870 the Royal Society's Catalogue of Scientific Papers enumerates no fewer than 107, ranging widely over the domain of physics, and several of which take their places as classics in the departments of science with which they deal.

His most extended work is his "Hand-book of Magnetism," published at Leipsic in 1867 as one of a series of works forming a general Encyclopedia of Physics, under the editorship of Karsten,

and in this department of knowledge he was one of the greatest authorities. In meteorology proper, the manner in which he presented and discussed the facts of observation of the diurnal barometric range, and the aqueous vapour of the atmosphere, and the theories he propounded therefrom, were eminently original, and will, we believe, always continue to be read, however much they may be modified or even overturned by future research. In astronomy, Professor Lamont's chief work was his Catalogues of Small Stars between 15° north and 15° south of the equator, being supplementary to the larger work under this head of Argelander and Bessel. As early as 1851 he demonstrated the existence of a decennial cycle in the diurnal range of the magnetic declination, which was more recently conclusively shown to correspond with the cyclical frequency and abundance of the sun-spots.

He was appointed Director of the Bogenhausen Observatory at Munich in 1835, and Professor of Astronomy in the University of Munich in 1852. He died at Bogenhausen early in the morning of Wednesday the 6th of August in the seventy-fourth year of his age.

Monday, 15*th December* 1879.

THE RIGHT HON. LORD MONCREIFF in the Chair.

The following communications were read:—

1. On the Expansion of Cast Iron while Solidifying. By J. B. Hannay, F.R.S.E., F.C.S., and Robert Anderson.

The fact that certain bodies expand on solidifying, as in the case of water, has long been well known, and this property has been recognised in some of the metals, owing to their filling the mould in which they are cast so as to reproduce the finest lines. The fact of their so doing is, however, only known qualitatively—no accurate measurements having, so far as we are aware, been recorded. The property being of great interest to ironfounders, we have undertaken a series of experiments to determine its real value—the materials being put at our disposal by Messrs M'Dowall, Steven, & Co., to whom we tender our best thanks. We used several methods, and

will show the reasons for selecting one as the most reliable. On pouring iron into a sand mould there is, at the moment of solidification some overflow; but no matter how tightly the sand was rammed, or to what temperature the mould was heated, the overflow varied so very much as to show that, as a method of measuring the expansion, pouring the iron into a sand mould was quite useless. The experiments conducted in this way showed an expansion of from 0·8 to 4·5 per cent., showing the method to be unreliable.

We then tried pouring the metal into a hollow sphere of iron whose capacity has been accurately determined. The sphere, however, seemed to yield in some parts, so that the overflow did not represent accurately the real expansion; but by weighing the filled sphere and the overflow, after we had arrived at an approximate value for the liquid iron's density, a more reliable estimate of the expansion was found. This method gave results varying from 4 to 5 per cent. of expansion, but the results were always low. The method which gave not only the most concordant results, but which would *a priori* be likely to yield the most accurate estimate of the expansion, was that of floating a solid sphere of iron in liquid iron of the same composition. The metal used was ordinary grey pig, and was contained in a large pot and brought to a temperature near its freezing point and spheres of metal dropped in. They were found to sink at once when dropped in cold, and they remained under the metal till they had acquired a temperature just approaching visible red; but at that temperature they rose to the surface, and as they gained more and more heat from the liquid metal their line of flotation rose higher and higher. Sometimes, if dropped in suddenly, the spheres did not float until they had begun to melt, but this was owing to their having cemented themselves to the bottom of the pot. When dropped in cautiously, or suspended by a wire, they sank only for the space of 20 to 25 seconds, and rose to the surface when barely red hot. The spheres were allowed to remain in the liquid till they began to melt, and then withdrawn and cooled, when a well-defined mark of the line of flotation was seen round the sphere. The spheres and their flotation segments were measured by several methods—1st, by callipers; 2d, photographed, and the photograph measured by a dividing engine; and 3d, by a telescope and micrometer. The last method yielding the most concordant results. The spheres from

several of the most successful experiments were measured with the following results. The numbers are merely scale readings, the spheres being 4·66 diameter.

No. I.

Diameter of Sphere.	Height of Segment.	Diameter of Segment.
2200	312	1585
2213	318	1583
2212	320	1597
2214	321	1592
2210	317	1598
2218	322	1590
2204	324	1588
2207	315	1589
2211	314	1592
2203	317	1594
Average 2209	318	1591

The variations in the measurements are due principally to the roughness of the surface after the sphere has been immersed in the liquid metal. Measurements of similar spheres gave as follows:—

No. II.

Diameter of Sphere.	Height of Segment.	Diameter of Segment.
2205	319	1584
2193	320	1591
2221	314	1596
2207	313	...
2226	317	...
...	320	...
Average 2210	317	1590

No. III.

Diameter of Sphere.	Height of Segment.	Diameter of Segment.
2221	317	1580
2204	321	1598
2207	314	1607
2200	315	...
Average 2209	316	1595

Calculated by the two methods—

$$(3r^2 + h^2) \cdot 5236h, \text{ and}$$
$$(3d - 2h) \cdot 5236h^2,$$

where r = radius of segment
h = height „
d = diameter of sphere.

The first method always yields the highest results owing to the diameter of the segment appearing larger than it really is; this being caused by the ridge of metal and scum which marks its flotation line. The difference between the two is not very great, but we take the value given by the last formula as the correct one. The amount by this method is 5·62 per cent. of expansion. Further experiments were tried by heating balls of iron to various temperatures and immersing them in the liquid iron to find at what temperature they ceased to sink; but this method fails for two reasons,—1st, the iron freezes a quantity of metal on its exterior, thus increasing its volume; and 2d, it gains heat so rapidly that before equilibrium is established its temperature has risen several hundreds of degrees.

The expansion obtained by the above method is rather under the truth, because, although the sphere is just at its melting-point, the liquid iron is of necessity considerably above it, so that it is not at its maximum density, which appeared to be very little if any above the melting point.

We find, then, that liquid cast iron expands at least 5·62 per cent. of its volume on freezing.

2. Researches on Contact Electricity. By C. G. Knott, Sc.D. Communicated by Professor Tait.

(*Abstract.*)

In these experiments the general method pursued was by direct contact and separation of two circular plane metal disks, the lower one of which was insulated and connected to one pair of quadrants of a Thomson quadrant electrometer. The upper disk or plate of this condenser arrangement pressed during contact on the lower by its own weight, and was in connection with the other pair of quadrants and with the earth. The lower plate formed the upper surface of a cylindrical flask, whose temperature was determined by

that of the water contained within it. In this way contact experiments with surfaces at different temperatures were made and results obtained. In the method which gave most reliable results, the upper surface was kept at the temperature of the air, while the temperature of the lower was allowed to vary as the water contained in the metal flask cooled through time. The contact, effected by lowering the upper plate upon the lower from a height of 5 inches, was instantaneous, so that the temperature of the upper surface did not change during the operation; while *immediately* before every such contact, both surfaces were carefully polished with emery paper and dusted, and their temperatures carefully observed. The best results were obtained when both the surfaces were of the same metal, as, for example, iron against iron. When that was the case there was, of course, no electrification by contact and separation when both plates were at the same temperature. When, however, the temperature of the lower surface was raised, a deflection on the electrometer scale was obtained, indicating a difference of electric potential at the surface of separation of these metal plates. Thus it was found that iron hot was negative to iron cold, copper hot negative to copper cold, zinc hot negative to zinc cold, and the same seemed to hold for tin. Not only so, however, but the difference of potential between, say, the two iron plates increased apparently with the difference of temperature between them, and increased *uniformly*. Curves were drawn out representing the variation of this potential difference with the temperature of the lower plate; and the points entered clustered approximately round three straight lines representing the temperature-variations for iron, copper, and zinc respectively. The tangents of the angles of inclination of these lines to the temperature axis are given in the following table:—

Metal.	Tangent of Inclination.
Copper,	·39
Iron,	·76
Zinc,	·9

Now it was proved by experiment in every case that this "negative-growth" of the metal surface when its temperature was raised was a *permanent* surface condition after the surface was cooled down to the same temperature as its fellow. Hence it follows that the main effect is not due to *mere* change of temperature, but to some

material alteration of the surface produced by this change of temperature—oxidation, for example. That this is the most probable view is borne out by known facts, and by certain results which I myself obtained relating to the subject of contact electricity. Hankel long ago showed that, with the great majority of metals, there was a negative-growth in time—for example, iron recently polished or filed was electrically positive to iron which had been left for some time in the air. This was probably due to oxidation; and it became a question of interest to compare this "time-variation" with the "temperature-variation" discussed above. A series of experiments were made very similar to those described above and differing only in this, that the lower surface was permitted to vary through time, without any alteration in temperature. The curves obtained by plotting the electrometer deflections against the time were very similar to the ordinary curves of cooling—somewhat logarithmic in appearance; and markedly dissimilar to the curves showing the "temperature-variation" of the same metals. Further, that metal varied in time fastest, which was the most positive: aluminium, zinc, iron, and copper being their order, taking first that one whose curve of time-variation was steepest. This result accords well with the theory given by J. Brown, Esq., of Belfast, in the "Philosophical Magazine" (1878–79), to the effect that the position of the metals in Volta's contact series depends mainly, if not entirely, upon their chemical affinity for air, the most positive being that which has the greatest affinity. That the most positive (aluminium, namely) should also be that which varies fastest in time is extremely probable; and it is also a plausible enough hypothesis that the most positive should also have the most rapid negative-growth with temperature. Now, as far as these experiments go, this is really the case. Zinc, iron, copper, are in the order of magnitude for temperature-variation, and also for time-variation; and the same order holds in Volta's contact series beginning with the most positive. It would thus appear that for any one of the metals zinc, iron, copper, and (we may add) tin, there corresponds a definite surface condition to every temperature—a condition which is permanent even after the surface has cooled, which has the effect of making the surface electrically negative to its original self, and which no amount of polishing can alter as long as the temperature is kept constant. Hence we

conclude that a chemically pure surface of these metals is impossible for more than a very few seconds after cleaning, even if for so long.

These experiments are to be repeated with the aid of an improved method of effecting contact.

3. On an Instrument for detecting Coal-Gas in Mines. By Professor George Forbes.

In 1877, shortly after the disastrous colliery explosion in the Blantyre pit, in which hundreds of lives were lost, Mr James Young, F.R.S., of Kelly, described to me an instrument which he had thought of for determining what is the amount of fire-damp in any part of a mine. This was the first thing which directed my attention to the subject, and I very soon saw that there was a principle in acoustics which might be most admirably adapted to the end in view, viz., to determine the quantity of fire-damp (or marsh gas) by the diminution in density of the mixed air and gas (for marsh gas is only about half the density of air). Mr Young and myself tested the principle the next day, and found it to be one of extreme delicacy. I then, in the spring of 1878, communicated to this Society the principle which I proposed to utilise in the form of a preliminary note. I have now the honour of exhibiting the instrument, which has been completed and perfected, partly by my own labours and partly by the appointment, for the purpose, of a Committee of the British Association, consisting of Professor W. J. Adams, Professor Ayrton, and myself. The form of instrument finally adopted is one in which a tuning-fork is set into vibration by drawing through between the prongs a tight-fitting piece of metal. Just under the points of the prongs a tube $1\frac{1}{4}$ inch diameter is fixed. The lower end of this tube is closed by a tight-fitting piston, whose position in the tube can be altered so as to regulate the length of the closed tube.

It is a well-known principle in acoustics that when a vibrating tuning-fork is so held over a tube, the air in the tube will resound and intensify the sound when the tube has a certain definite length. Moreover, this length depends on the kind of air or gas with which the tube is filled, being longer for a heavy gas, and shorter for a light gas, at the same pressure. Now a mixture of air and marsh gas is lighter than pure air in proportion as the dilution with marsh gas is

increased. Thus, according as there is a large or small percentage of fire-damp in a mine, so will the length of tube which best resounds to the tuning-fork be great or small.

There are one or two small practical details which have given some trouble, but which now render the instrument very perfect.

1. In order to give to the hand great control over the lengthening and shortening of the tube, a rack has been attached to the piston, which works in a pinion on whose axis there is a large disc with a milled head 3 inches in diameter. This disc has a glass face with a graduated scale round the circumference; so that a fixed index marks with great precision the exact length of the tube. The scale is thus made so large that readings can be made in the feeblest light.

2. In order that the instrument may be taken in advance of a lamp in places where gas is expected in large quantities, a phosphorescent powder is placed in a cavity behind the graduated glass plate, by which means readings can be taken in the dark.

3. To be sure that the gas or air in the tube is the same as what is to be found in the particular part of the mine under examination, I have introduced, through the piston which works the pinion, a rod at the upper end of which is a packed disc fitting the tube tightly. Previous to taking a reading this disc is, by means of a handle attached to the rod, driven up to the open end of the tube, and in being drawn back it sucks in the air from the place under observation. It is thus, by a single turn of the handle, locked to the piston which works the pinion, by a bayonet joint.

4. The temperature in a mine is generally very constant. But to prevent errors arising from variations in the temperature a thermometer is attached whose graduations are given in *percentages of fire-damp*, which are to be subtracted from the percentages recorded in the circular scale.

5. To test the accuracy of the scale, I have a circular trough 4 feet diameter and 3 inches deep. This is partially filled with water, and a grating is placed in the water to stand upon. In the centre of the trough there is a hole with an inch metal tube projecting upwards 4 inches. To this is attached an india-rubber tube 2 feet long, with a mouthpiece which can be firmly attached to the mouth for breathing. Sitting on the stool with the mouthpiece attached, and the nose closed by spring pincers, a tin cover 4 feet high and 3

feet diameter is lowered over me into the water. There is a small hole in this cover, with glass over it, at which a light is held on the outside. Different quantities of marsh gas are then admitted under the cover, which I mix with the air by means of a fan. A reading is taken with the instrument, and at the same time a bottle of water is emptied and closed air-tight. The contents of the bottle are afterwards analysed; and thus we obtain the true percentages corresponding to different readings of the scale.

In this way I find it possible to measure the proportion of fire-damp to about ½ per cent.

I have taken the instrument down several fiery mines, both in Yorkshire and Lanarkshire, and have found it most accurate and consistent in its indications. Messrs Merry & Cunninghame, after trying it, have adopted it. It is extremely portable, can be carried in a large coat-pocket, and is not likely to be injured, and causes no trouble. In fact, in this, its latest form, it seems to answer all requirements. Variations in the pressure of the air do not affect it.

I ought to add that although choke-damp (*i.e.*, carbonic acid gas) is not often found in company with fire-damp, yet even when this is the case, and in sufficient quantities to prevent the instrument from indicating the presence of fire-damp (choke-damp being as much heavier than common air as fire-damp is lighter), its presence prevents the fire-damp from being explosive; and thus the indications of the instrument can in all cases be relied upon for indicating danger.

4. On Comets. By Professor Tait.

(*Abstract.*)

The author commenced by stating that he had been led to make farther investigations, on the subject of his hypothesis as to the nature of comets, by some comparatively recent criticism to which that hypothesis had been subjected. Its main features had been published more than ten years ago in the "Proceedings" of the Society (May 17, 1869) and in the first volume of "Nature." Of course, if a critic completely misstates an hypothesis, he has no difficulty in refuting it; so that to such writers the author does not attempt to reply. The other class of critics, including Mr Glaisher, and the late

Prof. Clerk-Maxwell, while on the whole favourable to the theory, pointed out the necessity for a full dynamical investigation, whose results might be compared with observation. The author's own conviction has all along been that the difficulty is not so much dynamical as constructional:—*i.e.*, it lies mainly in obtaining a proper conception of the problem to be treated in the case of any particular comet, and not in the way of obtaining at least an approximate solution when once the problem is stated. The fact is that the hypothesis is so very general that almost anything could be explained by it. When two considerable masses of stone, moving approximately in the same orbit, impinge on one another with given velocities, what is the amount of smashing—how many large fragments, how many small, how much mere dust, will be produced—and in what direction and with what relative velocity will each of these on the average be projected? What amount of glowing gas will be produced? Again, if there be many millions of such masses, forming a group in which all describe approximately elliptic orbits in something like equal periods, but of various sizes and in any planes about their common centre of inertia, the group itself being subject to a sort of tidal disturbance by the sun, at what part of the group will the impacts mainly occur? Questions so entirely vague as these are not yet ready for the application of mathematical methods.

The main difficulty felt by the critics above named seems to be with respect to the production of the *tail* of a comet. The hypothesis of course involves as an immediate consequence that extensive regions of space all round the nucleus of the comet (but specially extended in the plane of its orbit) are full of fragments large and small, driven out at different times from the main ranks which (on the whole) become gradually extended along an arc of the orbit. Rays or tails will thus be seen wherever a visual line can be drawn, along and near to which there is an assemblage of particles fitted to give back a maximum of solar light. And, if the particles be not very large, the mass in each cubic mile of space may be very small, while the whole has considerable brightness, and yet does not sensibly weaken the light of a star seen through it.

The author stated that he had investigated the form assumed by a train of particles ejected at different times from the head of a comet in the plane of its orbit; always with the same relative velocity (so small

that the square of its ratio to that of the comet may be neglected), and in a direction making a given angle with the tangent to the orbit. The result is that such particles will lie approximately on a semi-parabola, the vertex being at the head of the comet. When the ejection is towards regions outside the orbit, the parabola lies behind the head of the comet; but if the ejection be inwards the parabola precedes the head. This parabola diminishes in parameter as the curvature of the orbit increases.* There can be no doubt that here we have a very striking resemblance, if no more, to the form usually assumed by the tails of comets; and for comets with many tails (like that of 1744) we require only a greater number of definite directions of maximum ejection. *Why* this ejection is generally (though by no means always) outward, (for several comets have had two tails, of which one was turned *towards* the sun) we cannot attempt to explain till we know at what part of the group of masses the impacts are most likely to take place.

The present theory differs altogether from that of Olbers, Bessel, and others, in assuming the fragments which form the tail to have but little velocity relatively to the nucleus, while the received theory assigns them very rapid motion along the tail:—Olbers says as much as a million miles per day. The one theory endeavours to represent the motion as a result of the received law of gravity; the other introduces the hypothesis of a solar repulsive force often

* These conclusions are found to follow easily from the very simple investigation for a circular orbit. For the approximate differences of radius-vector, and angle-vector, at the time t, of the comet and of a particle projected at time t_1, with relative velocity p, from its head, in a direction making an angle ψ with the tangent, are—

$$r-a=-\frac{p}{\omega}\left(2\cos\psi\,(1-\cos\omega(t-t_1))-\sin\psi\sin\omega(t-t_1)\right),$$

and

$$\theta-\omega t=\frac{p}{a\omega}\left(\cos\psi\,(3\omega(t-t_1)-4\sin\omega\,(t-t_1))+2\sin\psi\,(\cos\omega(t-t_1)-1)\right).$$

Here a is the radius of the orbit, and ω the angular velocity in it.

If $\omega\,(t-t_1)$ be a small angle χ, whose third and higher powers may be neglected, these expressions take the form—

$$r-a=-\frac{p}{\omega}\left(\chi^2\cos\psi-\chi\sin\psi\right),$$

$$\theta-\omega t=-\frac{p}{a\omega}\left(\chi^2\sin\psi+\chi\cos\psi)\right),$$

from which we easily deduce the results stated above. It appears that in the majority of large comets ψ is nearly a right angle.

more intense than gravity, and one which, unlike gravity, depends on the quality as well as the quantity of matter. It seems to the author that the introduction of such hypotheses is inconsistent with Newton's "Regulæ Philosophandi" until it is definitely proved (as has certainly not yet been done) that known forces are not competent to produce the observed results.

5. Additional Observations on Fungus Disease of Salmon and other Fish. By A. B. Stirling, Assistant-Curator in the Museum of Anatomy in the University of Edinburgh. Communicated by Prof. Turner.

In a paper read to the Society in June last, "Proceedings," June 1879, on the fungus disease affecting salmon and other fish, I discussed the various theories which were advocated, as to the cause of the disease; the effects of the fungus upon the fish, the vegetative and reproductive aspects of the fungus, and the belief that salt water had a curative effect upon salmon affected with fungus disease, on their reaching and remaining for some time in that element.

I also mentioned that at the instance of the Tweed Commissioners, an experiment was being conducted by G. H. List, Esq., to test whether that belief was well founded. I will now state the nature and result of the experiment, and afterwards relate to the Society, an account of an epidemic of fungus, which occurred at Ightham Mote, in the county of Kent in 1874, and which appeared again in a virulent form a few weeks ago.

The experiment referred to was conducted as follows:—A wooden cage, large enough to allow a salmon to move about within it, and perforated with holes so as to allow the water to flow freely through it, was prepared. It was then moored in the tideway in the River Tweed, below Berwick bridge, where the water is at all times more or less salt, and was now ready to receive a fish for experiment.

About the end of May last a sea-trout kelt was captured at Eithermouth, three miles up the river, and within the influence of the tide. It was placed in a suitable vessel and conveyed to Berwick, where it was enclosed in the cage. The fish is stated by Mr List to have been affected with a sloughing sore on the top of the head from the point of the snout about two inches in length and

the same in breadth. This sore had all the characters of a sore produced by the fungus disease.

The cage was visited at intervals, and the effects of the salt water upon the fish noted. The cage with the fish was towed out to sea for two hours on each of six occasions.

In a short time, the sore upon the fish was observed to be healing. The fish remained in the cage till the 2d or 3d of October, when an accident occurred by the breaking of one of the chains which held the cage in position. This allowed the cage to swing to one side, and nearer to the shore, when upon the ebbing of the tide the cage was left dry, which occasioned the death of the fish. On discovery of the accident, the fish was sent to me for examination. I received it on 4th October, after it had been confined in the cage for fully four months. From the combined effects of imprisonment, and want of food, it had become very much shrunken, was very lean, and had more the appearance of a compressed eel than the form of a salmon. The fish was very dark in colour, the scales were uninjured, and the mucus covering was evenly thin and transparent, and there was no fungus on any part of its body. All the viscera were healthy the sores upon the head were healed, and the skin grown over them. A slight sore on the under surface of the right lower jaw, which appeared to have been caused by friction on the bottom or sides of the cage, was in a raw condition, but had not the least appearance of an unhealed ulcer. Fully one-third of the lower border of the upper lip, at the middle of the snout, and the outer and upper margin of the gums at the same part, were not quite healed, and the roots of the teeth were exposed from the parts having been ulcerated.

The pectoral and caudal fins had been diseased, and some of their rays broken; both were now healed and covered with membrane, and the shortened rays had the appearance of growing again. I consider the result of the experiment to be so far satisfactory; it shows that migratory *Salmonidæ* affected with an ulcer produced by fungus disease, get rid of it in salt water, even when confined and without food for a long period, and I infer from those facts, that had the fish experimented upon been free in the ocean for an equal period of time, it would have recovered both health and condition.

The removal of all dead fish from the rivers has been universally

advocated; the removal and killing of all affected fish has been recommended by many. On the other hand, the Tweed conservancy hold the opinion that the capture and removal of all fish affected with fungus (not in a dying state) to salt or tidal water was the proper course to follow, and with this opinion I fully concur. There is one point in this plan which may cause some disappointment. Supposing it proved that salmon are cured of fungus disease in the salt water, and that those so affected in the upper waters, were captured and conveyed to the tidal part of the river, only those fish with the instinct of descending to the sea, when captured, would remain to be cured. Those with the instinctive desire to ascend, when captured, would in all probability return to the fresh water. Those instincts in the salmon are known to be both strong and certain, their sense of being diseased, and need of cure "instinctively or otherwise" are unknown.

I shall now give an account of the very remarkable epidemics which occured at Ightham in Kent, the particulars of which were kindly communicated to me by Dr W. S. Church, Physician to St Bartholomew's Hospital, London. They are of so much interest in the history of the fungus disease, that I feel warranted in bringing them to the notice of the Society. Ightham House dates from the time of King John, and the fish ponds were probably constructed at the same time, to supply the house with fish. The house is built in the form of a square, and surrounds a courtyard. The house in its turn is surrounded on all sides by a moat, the water in which is from 5 to 9 feet in depth. The present arrangement of the ponds, garden, &c., was probably made in the time of James I. The house drains into the moat, and the drains issue into it by separate openings from two sides of the square. The stream which supplies the ponds and moat is formed by the surface water of a small valley, but is principally supplied by two very fine and strong springs, which come out of the Kentish limestone. The stream is only about a mile in length before it enters the upper pond, and there is at all times a strong run of water in it. It is perfectly free from drainage contamination, and enters the upper pond perfectly pure. There are two cottages and a small fold yard on the side of the stream, but no drains flow from them to the water; the fold is in a ruinous condition, and is not in use.

The ponds are much larger than the square of the house and moat. The upper pond is situated about 100 yards above the moat, the greater part of the space between them being occupied by a bowling green. This pond is shallow, and has reedy banks, with flags and aquatic plants growing on the margins; a strong current flows constantly through it to the outlet, and the water leaves it by a stone channel falling perpendicularly about 5 feet.

Immediately beyond the fall, the water divides and forms two open streams, which supply two small ponds or stews at a short distance below, on the right and left sides of the fall. The water leaves the stews by conduits, which pass underground to the moat, and enter it by two falls of between 3 and 4 feet each, which fall clear of the breastwork. In addition to the main stream, through the conduits there are two other strong feeders of the moat, which flow into it from springs on opposite sides, and there is a continuous current flowing through it. The water leaves the moat by culverts to the lower pond, and from the lower pond by a fall, and flows through grass fields for a mile, where it enters another fish pond.

No epidemic of fever or other zymotic disease is known to have taken place in the house, and only two cases of sickness (measles) during the last fifteen years. The gardener, his wife, and child, were the only occupants of the house during last winter, spring, and summer, the family being from home.

Several severe epidemics of fungus have been observed in the ponds and moat. One occurred about the year 1850, but no particulars have been preserved, and mild ones may have passed without much notice. "Furred" fish, and even a few dead ones, have been often seen by the gardener. In the spring of 1874 a very severe epidemic occurred, when all the ponds and the moat suffered heavily; nearly all the fish died in the moat, and the disease was very destructive in both the upper and lower ponds.

This attack was inquired into by Dr Church, who satisfied himself that the fungus affecting the fish was *Saprolegnia ferax.* The fish consisted chiefly of roach, pike, and dace in the moat; roach, perch, and pike in the upper pond; roach, dace, perch, pike, and gudgeon in the lower pond. The roach, dace, and gudgeon suffered the most, only the small pike and perch were affected, and none of the large pike or perch were found dead, and not a single eel.

Many of the fish looked, when in the water, as if covered with a halo, remaining at the surface nearly motionless, frequently putting their mouths out of the water, and turning belly uppermost immediately before death. On examination, the fungus was found to be most thickly matted on the shoulders just behind the head, clogging up the gill openings, on the pectoral fins, and tail portion of the body. Whenever ulceration had taken place, it was seen to be due to the fungus, as the parts most ulcerated were those most densely covered with fungus. Death was caused by suffocation in every instance.

The last fungus epidemic which occured at Ightham moat and ponds began in the latter end of October of the present year, and continued to the middle of November. About eight or ten days after it had commenced, and numbers of the fish were observed to be dying, Dr Church very kindly favoured me by sending a number of specimens that had died in the water, and also a number that were affected with the fungus but were still alive when taken from the water. Dr Church informs me that in this epidemic it was chiefly the fish in the moat which were affected and died, and only a few in the lower pond were observed to be affected; none were found affected in the stews and upper pond, although the stews were swarming with fish. As during the epidemic of 1874, the roach and dace suffered first and worst; the pike, perch, and eels have not been affected during this epidemic.

The diseased fish sent to me by Dr Church were roach, 17 in number; 7 were dead when taken out of the water, and 10 were alive when taken. They average 2 oz. in weight each, and were all packed in fresh grass; those taken alive were put at the bottom of the box, with grass under and over them, and the others at the top of the box were packed in a similar way. The fish at the top of the box were overlying each other, and appeared as if they were enclosed in a common envelope of fungus, and such was actually the case; the fungus having continued to grow vegetatively, had, as it were, woven the whole group in a web of fungus. The new growth had a perceptible pink tint, the same as I had seen upon a greyling sent to me from the river Tweed last spring, and may possibly be the natural colour of the fungus when it grows in the air. I confirm Dr Church's statement that the fungus was *S. ferax* and identical with

that found upon diseased salmon from the Tweed and Solway rivers during the epidemics of 1878 and 1879. I observed that the majority of the filaments of the fungus found upon the Ightham fish were spear-shaped, very few had clavate fruit heads, and I saw none with ripe zoospores, indicating that the reproductive power of the fungus was feeble, and was producing only barren filaments, which appears to be always the case when the epidemic has run its course.

Only four of the ten specimens had any external blemish upon them, which consisted of slight ulceration upon one pectoral fin in two, and in the caudal fins of other two; several of the rays were broken, and portions of them were hanging by the filaments of the fungus. In all the specimens the fungus covered the greater part of their bodies; and the heads of several, including the eyes and nostrils, were completely covered over. In none of the fish were the gills affected, but five of them had the opercular opening of the gills nearly closed up by the fungus.

On opening the abdomen the viscera were seen to be white, firm in position, and with a fair amount of fat upon the stomach and intestines. The roe in the females was firm and clear, and though very small, it was more advanced then the milt in the males. The heart, liver, and spleen were normal in size, and not the least appearance of extravasation in any of the organs. On opening the stomach and intestines I could not determine what the food of the fish had been, as only white glairy mucus in small quantity was found in any of them.

The blood was perfectly normal in all, and the subcutaneous tissue was in no instance discoloured, even under the thickest patches of fungus, showing that up to the time the fish were captured no ulceration, or indication of any, either on the head or scaled parts of the body, had taken place. The seven specimens preserved and submitted to the Society will be found to be without a sore or an ulcer on any part of them, which *S. ferax* could claim as a pre-existing nidus upon which to plant itself. I may notice here that there seems to be two ways by which the fungus causes death by suffocation. The first and quickest way is when the fungus gets seated within the mouth and upon the gills at the same time, which I have observed occurs oftener in the large fish than in the small. The second, and

probably a slower way, is when the fungus grows over and closes up the opercular openings of the gills, which seems to be the way those specimens have been suffocated, being shrouded while alive in fatal fungus, they have died in their beauty, with their silvery skins unbroken.

There is one fact connected with the Ightham epidemic, namely, that the large pike, perch, and eels were not affected by the fungus disease. I am unable to account for this immunity on physiological principles, and refer it to the hypothesis of the "struggle for existence and survival of the fittest." It would be difficult to find anywhere a purer collection of water than the Ightham ponds. The main stream, upper pond, and stews, being virgin spring water, uncontaminated with any pollution, so that I am convinced that *S. ferax* can and does exist where no source of pollution is present, and exercises its destructive influence upon the fish as is evidenced by the numerous deaths in the epidemic of 1874 in the Ightham upper pond. Up to the present time, it has generally been held that fungus epidemic, or, as it has been called, salmon disease, was confined to and had its origin in rivers frequented by the migratory *Salmonidæ*. At an early stage of the inquiry, Sir Robert Christison referred to this, and urged that if possible it should be ascertained whether the disease had ever been observed in the head waters of any salmon river above any impassable obstruction, either natural or artificial. The epidemic at Ightham moat and ponds answers the question Sir Robert desired to be cleared up, and proves that *S. ferax* is not confined to rivers frequented by salmon.

In a former paper, I stated that the so-called salmon disease did not depend upon a pre-existing functional disorder in the fish. I am still of this opinion, and point to the fish from Ightham as a further proof that this is the case. I also stated my belief that *S. ferax* existed at all times and probably in all waters, and that the presence of fish and *S. ferax* in the same water under certain climatic or other at present unknown influence, seems all that is necessary to originate fungus epidemic.

The epidemic at Ightham in my opinion does away with the theories of overcrowding, including overstocking. Overcrowding of salmon in a pool in a river is not analagous to overcrowding of people in a room or in a prison cell, where only a certain amount of

air can circulate. Salmon crowded in a pool in a river, through which a stream of water flows freely, are in a condition similar to a herd of cattle crowded in a pen or fold, in the open air on a hill-side, where pure air is inexhaustible. In like manner salmon crowded in a pool are provided with a continuous supply of oxygen by the constant flow of the river through the pool.

As to overstocking, my own opinion as an angler of fifty years' experience, and as a net fisher for a fifth of that time, is that I never found the fish too plentiful anywhere; and I do not think there ever can be too many, especially trout, grilse, and salmon, in any of our rivers. Very curiously, those who advocated the theory of overstocking as the cause of the fungus disease, are in many instances the very persons who grumble at the scarcity of the fish in question, and propose to increase their number by killing them for eight or ten days longer at the latter end of the season, when the fish best adapted for breeding are entering the rivers. Regarding the food supply in overstocking, I quote the following statement cited by Sir Samuel Wilson of Ercildoune, Australia, in his work on the acclimatisation of Californian salmon. "It is stated by Mr Vincent Cooke of the Oregon Packing Company, that out of 98,000 salmon caught in the Columbia River in 1874, three only were found with some trace of food in their stomachs, and those seemed to have quitted the salt water very recently."

The fact that the house drains into the moat might be urged by some as an argument that the water there is rendered foul by the house sewage, and that the pollution of the water may have had some influence in developing the disease. In reply to this it must be stated, that, as Dr Church points out, a large body of water flows through the moat hourly, and so far from ordinary house drainage being prejudicial to fish, where the water is frequently changed, the finest fish, as the pike, perch, and eel, are to be caught in the neighbourhood of the house drains. But if it were proved that the house drainage mingling with the water of the moat served as an exciting cause for the development and propagation of the fungus in the moat, this could not be advanced as a reason for the appearance of the disease in the upper pond, which was fed by an uncontaminated stream. Neither could diseased fish from the moat find their way to the upper pond so as to infect the fish there, as there is not only a

clear fall of between 3 and 4 feet between the moat and the stews, but one of about 5 feet between the stews and the upper pond, thus presenting obstacles such as the fish living in these waters could not surmount.

In conclusion, I feel convinced that the so-called salmon disease is *the fungus* itself, and that no structural disturbance in the fish is necessary to cause fungus attack; that this appears to me to have been abundantly proved by the sixty specimens which I have dissected and examined; that it is useless to look for more information on the origin and cause of fungus epidemic, from the carcases of salmon or other fish affected with the fungus; that the origin and cure or prevention of the plague must be sought for in the life history of the plant, which is more the work of the botanist than the anatomist.